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UNITED STATES DEPARTMENT OF AGRICULTURE
MISCELLANEOUS PUBLICATION No. 168

WASHINGTON, D.C. NOVEMBER 1933

MARKET DISEASES OF FRUITS AND VEGETABLES

APPLES, PEARS, QUINCES

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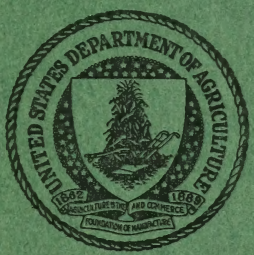

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APPLES, PEARS, QUINCES[1]

By Dean H. Rose, *senior physiologist*, Charles Brooks, *principal pathologist*, D. F. Fisher, *principal horticulturist*, and C. O. Bratley, *associate pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry*

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[1] This publication is the third in a series designed to aid in the recognition and identification of pathological conditions of economic importance affecting fruits and vegetables in the channels of marketing, with the view of facilitating the market inspection of these food products and preventing losses from such conditions. It represents an extended revision and elaboration, with the addition of numerous colored illustrations, of a preliminary (multigraphed) Handbook of Diseases of Fruits under Market, Storage, and Transit Conditions, prepared in 1919 by Dean H. Rose and the late O. F. Burger for the use of the food-products inspectors of the Bureau of Agricultural Economics. The material is organized on the basis of the botanical families to which the plants belong, but no botanical system is followed in arranging these families. Practical considerations make it desirable to issue the material in separate sections arranged somewhat in the order of the economic importance of the crops. The Host Index of the Fungi of North America, by A. B. Seymour, 1929, is used in the main as a guide to the nomenclature of causal fungi and the names of authorities therefor. The common names of the insects mentioned are those approved for general use by the American Association of Economic Entomologists (Jour. Econ. Ent. 24; 1273–1310, 1928).

The statements regarding fruit injuries caused by insects are made with the approval of the Bureau of Entomology. B. A. Porter, of that Bureau, has collaborated with the authors in the preparation of the entomological portions of the bulletin. The colored plates are reproduced from water-color paintings made by L. C. C. Krieger, R. C. Steadman, J. Marion Shull, and Mary D. Arnold, of the Bureau of Plant Industry, under the direction of Dean H. Rose, Charles Brooks, and D. F. Fisher, and from colored photographs prepared through the collaboration of Webster Bros., Chicago, Ill., under the direction of Dean H. Rose and the late O. F. Burger.

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INTRODUCTION

The word " disease " as used in this publication means any departure from the normal or usual condition of fruits that renders them inedible or otherwise undesirable for the use of the consumer. Under such a definition, internal breakdown of apples is as truly a disease as blue-mold rot or scab. Internal breakdown, however, is produced by environmental factors and the life processes of the fruit itself, whereas scab and blue-mold rot are produced by the action of certain fungi which, in this publication, are referred to as the causes of the respective diseases.

The relation of various factors, physical and otherwise, to the occurrence and development of the diseases of pome fruits are set forth in more or less detail in the pages that follow. It is important at this point to mention some of the more important facts concerning fungi (molds) that need to be kept in mind in dealing with fungous diseases of fruits.

An important characteristic of most fungi is that they produce minute bodies called spores, which are a means, usually the most important one, by which fungi reproduce themselves and are distributed. Being small and light, they are easily carried by wind, rain, insects, and other agencies. Spores of several kinds of fungi that attack fruits are quite common on the soil surface and on all plant parts aboveground. They are most important on the surface of fruits, because under favorable conditions they produce fine fungous threads that enter the fruit and cause disease. When fruits lie near one another or touch, or when they touch the ground, the disease may be spread merely by the growth of these threads, especially of fungi that make a luxuriant growth extending in all directions from the spot attacked. In any case, the original source of the threads was a spore or spores.

Without spores, most fungous diseases of fruits are not likely to occur to a degree great enough to be commercially significant. But the spores lie inert unless moisture is present to make them germinate. The fungus threads they produce may or may not be able to enter the fruit through the unbroken skin, but are always more likely to enter if skin breaks are present. Temperature, too, has a direct influence on spore germination and the growth of the threads; and although when fruits are ripening in the field the temperature rarely goes low enough there to check either of these processes completely, it may reach a point (45° to 50° F.) where it checks them so much that little infection occurs; or it may go high enough (80° to 90°) so that both processes are accelerated and infection occurs wherever the fungus can enter. Factors that favor the development of each disease in transit, in storage, or on the market are discussed under the appropriate headings in the body of this publication.

Certain general suggestions can be made, however, that are worth the consideration of every person concerned in the growing and marketing of fruit. All fruits should be handled carefully through all stages of the harvesting and marketing processes. Apples or pears are not visibly ruined, like eggs, when they are dropped a foot

or two. They may sustain bruises or skin breaks, however, that under favorable conditions in storage or in transit mean just as nearly total loss as if the fruits had been mashed or broken in pieces while being harvested or packed. In this connection it should be remembered that the susceptibility to fungous rots increases as the fruits become more mature, and hence ripe fruits require especially careful handling at all stages of the marketing process if excessive loss from rot is to be avoided.

It is highly important, also, that packing houses, packing-house machinery, and the immediate surroundings of packing houses should be kept free of all cut, mashed, or decaying fruits and all fruits culled out of the pack for any reason. A few apples or pears affected with blue-mold rot or gray-mold rot, if run through grading machines or left lying on the floor in out-of-the-way places, can produce enough spores to make them a serious source of danger to all the fruit that passes through the house. Stacks of field boxes filled with rotting culls give up spores to every wind that blows over them. If they stand inside the packing house, or near doorways, even though outside, they mean trouble. The safest procedure is to get them away from the house as soon as possible and to clean up the grading machinery and bins and the packing-house floor at least once every day. It is desirable to have the floor of the house tight, to keep mashed and decaying fruit from dropping through to the ground below and there becoming a source of fungus infection.

At various places in the pages that follow, descriptions are given of injuries that may result from the washing of apples or pears to remove spray residue. It cannot be too often emphasized, however, that if the washing is done with proper equipment and care and under desirable sanitary conditions, neither the market value nor the keeping quality of the fruit will be impaired; on the contrary, both are generally enhanced (*68*, *69*).[2]

The common names of diseases used in this publication are for the most part those that have become well established in the literature of plant diseases and are in general use among persons concerned with the growing and marketing of apples, pears, and quinces. A few, such as Jonathan spot and York spot, indicate the name of the variety on which they were first described or on which they are most common. Some of the names, such as bullseye rot, flyspeck, and scald, are briefly descriptive of the diseases to which they are applied. Still others contain the name of the causal or inducing agent; among these are Alternaria rot, drought spot, and freezing injury.

A few of the names imply a quality of the affected tissues which is not really characteristic or typical, but they are so well established by usage that it has seemed best to retain them. The diseased flesh of apples affected by bitter rot and bitter pit is not often bitter; "black rot" lesions are usually only dark brown, whereas "brown rot" lesions eventually become black.

Most of the insect injuries are named for the insect that causes them.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 59.

APPLES

ALTERNARIA ROT

(*Alternaria* sp.)

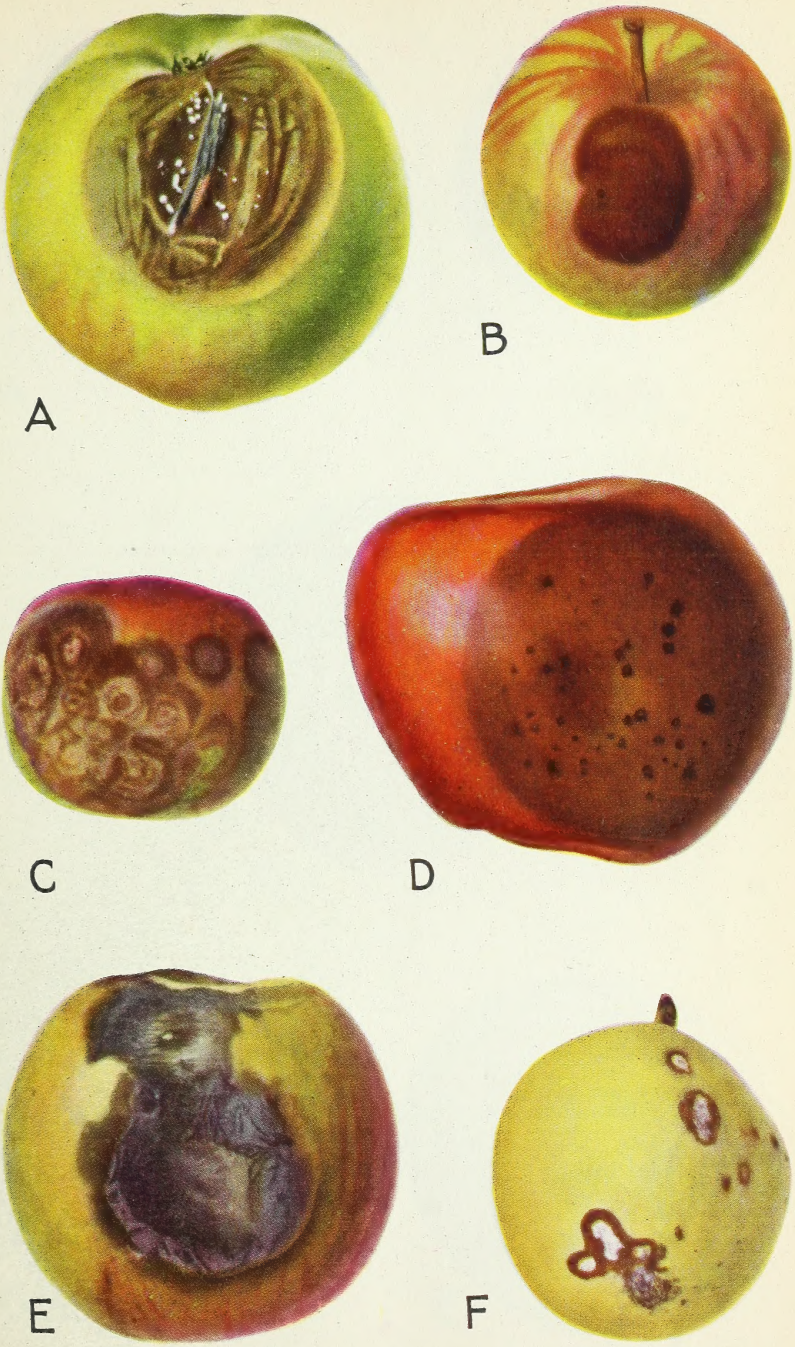
Alternaria rot occurs almost wholly on stored apples, but has been reported as attacking apples and pears on the tree in Colorado. It is most frequently found on apples held in common storage, but even on them it seldom causes much loss.

On apples from the Northwest, Alternaria rot occurs in three fairly distinct types, one of which, found so far only on apples in cold storage, is characterized by rather small, firm, slightly sunken areas which may be brown around the edges, but are covered for the most part by a rough, black crust (pl. 1, E). The second type occurs on apples in cold storage and also develops from the black-crust type after apples are removed from storage. It is characterized by firm, slightly sunken, rotten areas which are most commonly dark brown to black, but may occasionally be light yellowish brown to almost gray. The third type is found as a black rot on areas of apple skin that have been weakened by scald. A similar rot is produced, however, by the fungus *Cladosporium*, and it is not safe to attempt to distinguish between the two without laboratory study. For all practical purposes in inspection, both Alternaria and Cladosporium rots can be described simply as "a black rot." So far as known, both rots develop under the same conditions and neither is able to spread from one apple to another to such an extent as to make it commercially important.

Alternaria rot is perhaps most frequently found following scald, soft scald, arsenical injury at the calyx, and as a rot at the core, especially in apples showing severe codling-moth injury. On apples from the eastern part of the United States it sometimes occurs in the form of a sunken ring of brown, diseased tissue half an inch or more in width close around the stem.

Alternaria rot can be distinguished from other rots of northwestern apples by a uniform brown or black color; that is, by the absence of a "bullseye" appearance. On eastern apples it can be distinguished from black rot by the absence of pycnidia and of alternating zones of light and dark brown in affected skin, and from bitter rot by the absence of concentrically arranged pink or cream-colored spore masses. If aerial mycelium develops, it is dark colored.

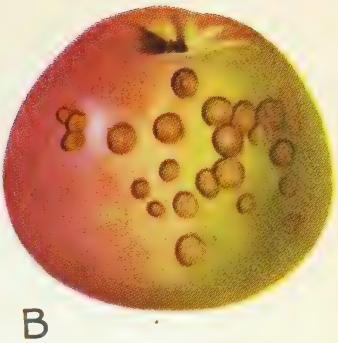
The fungus occurs in orchards on plant debris. It apparently gains entrance into the fruit through breaks in the skin, or through areas of the skin that have been killed by physiological diseases such as scald or by chemical injury. Control of the Alternaria rot must therefore depend chiefly on careful handling during the process of picking, washing, and packing, and the prevention of skin diseases and injuries which open the way for rot infection. (*17*, *22*, *59*, *62*, *100*, *135*, *137*, *195*, *205*, *235*.)



APPLE DISEASES

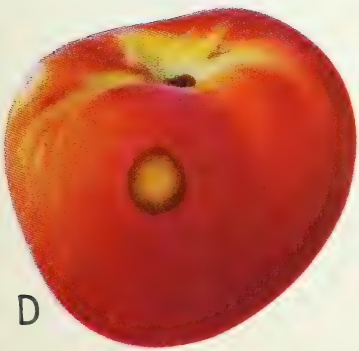
A, Blue-mold rot on Yellow Newtown; B, black rot on Rome Beauty; C, bitter rot; D, brown rot on Winesap; E, Alternaria rot on Rome Beauty; F, pink-mold rot on Yellow Transparent.

A

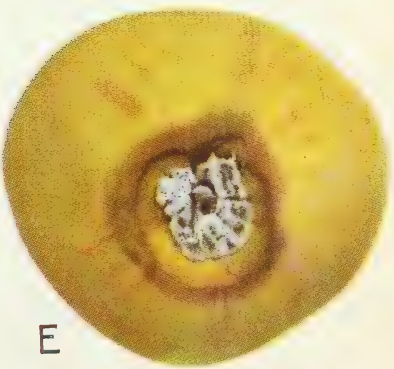


B

C



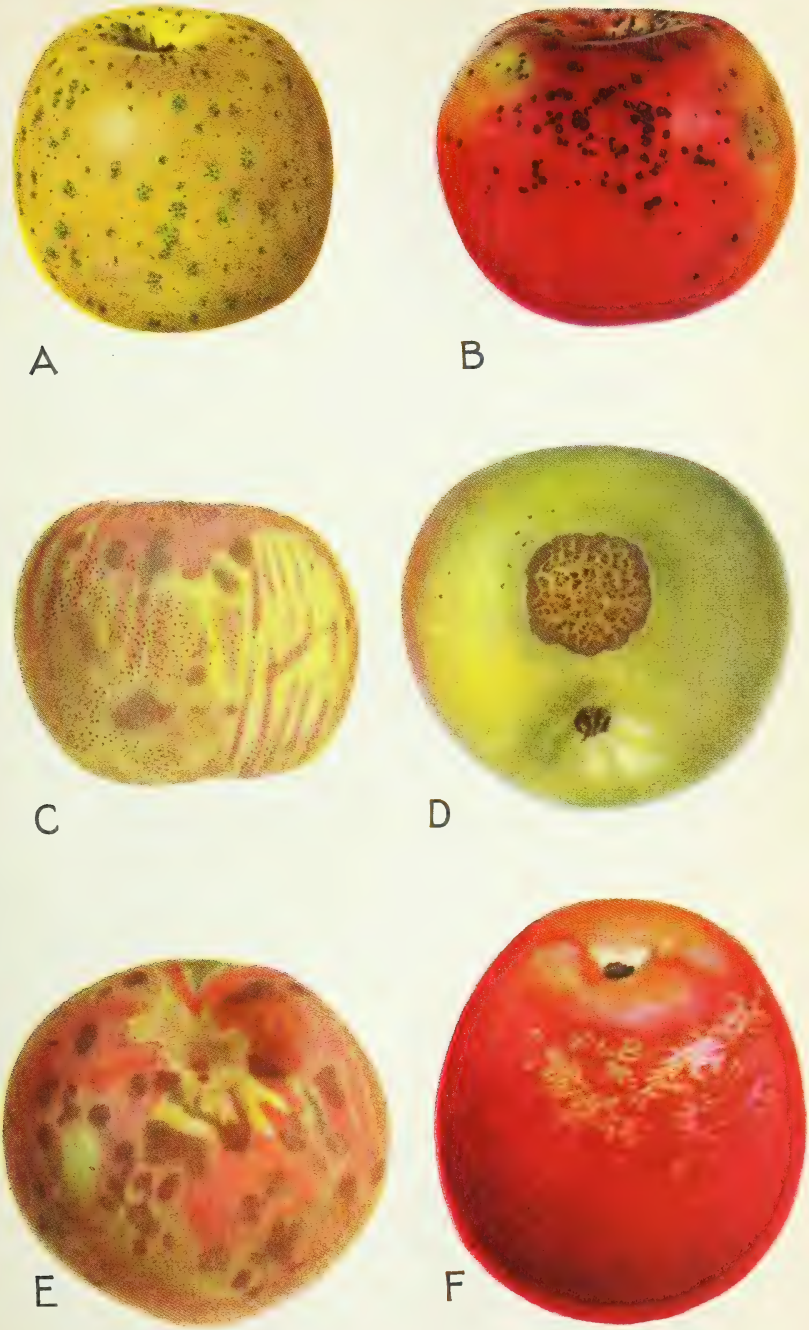
D



E

APPLE DISEASES

A, C, D, E, Bullseye rot (perennial canker) on Esopus Spitzenburg; B, fish-eye rot on Stayman Winesap.



APPLE DISEASES

A, Fruit spot (Brooks' spot) on Grimes Golden; B, storage scab on Rome Beauty; C, flyspeck and sooty blotch; D, scab as developed on Rome Beauty on the tree; E, sooty blotch; F, powdery mildew on Esopus Spitzenburg.

AMMONIA INJURY

(See Pears, Ammonia Injury, p. 49 and pl. 12, F.)

APPLE-CEDAR RUST

(*Gymnosporangium juniperi-virginianae* Schw.)

Apple-cedar rust occurs in practically all apple-growing sections of the central and eastern United States. It is found only rarely on the market, and even then merely as a slight blemish, since badly marked fruit is usually culled out before shipment. The varieties most often affected are York Imperial, Wealthy, Jonathan, Ben Davis, and Rome Beauty. The rust fungus belongs to a large group of fungi that must complete different stages of their life on different hosts. The second or alternate host of apple-cedar rust is redcedar, on which the fungus produces the familiar rough, brownish galls known as cedar apples. From these it spreads in the spring to apple leaves and young fruits, but it must pass again to the cedar if it is to continue its development.

Infection with the rust fungus takes place when the fruit is young. Its result is either to cause the fruits to drop while still undeveloped or so to stunt their development that they fail to reach the average or normal size for the variety and often become noticeably flattened or otherwise malformed.

Rust usually appears on the calyx end of the apple as grayish-yellow to yellow areas that vary in superficial diameter from about one eighth to three fourths of an inch and extend into the flesh for a fourth to half an inch, or even to the core (pl. 4, D, E). The surface of the spots may be smooth, or it may be roughened with the spore-producing bodies of the fungus (aecia), these being in the form either of pimples or of open cup-shaped receptacles with flaring papery edges. None of these will measure over a sixteenth of an inch in diameter. The flesh beneath rust spots is woody and usually greenish in color, though in the Winesap and the Ben Davis the green is sometimes intermixed with a pronounced browning.

The disease can be controlled by removing all cedars in the neighborhood of an orchard; in practice it has been found necessary to extended the eradication to a distance of 1½ to 2 miles. (*12*, *25*, *81*, *82*, *100*, *114*, *122*, *158*, *160*, *183*, *195*, *208*, *209*, *219*, *223*, *226*, *229*, *230*.)

Quince rust (*Gymnosporangium globosum* Farl.) sometimes attacks apples, producing dwarfing and distortion and an internal condition like that shown in plate 4, F, which affects more of the fruit tissue than that caused by apple-cedar rust. Aecia are not usually produced.

APPLE-MAGGOT INJURY

(*Rhagoletis pomonella* Walsh)

OCCURRENCE, SYMPTOMS, AND EFFECTS

The injury caused by the apple maggot, which is often found in apples from the northeastern part of the United States, consists of small tunnels winding through the flesh of the apple, although there may be little or no external evidence of infestation (pl. 20, A).

The maggots have been found to distribute bacteria and molds through the interior of the fruit, causing the flesh to rot and break down and, in badly infested fruits of the early varieties, to drop prematurely. In the case of fruit of winter varieties which fails to drop, the maggots are usually killed by the pressure of the rapidly growing fruit, although the tunnels remain as brown woody streaks through the flesh, rendering the fruit less suitable for cooking or eating. Most of the damage is done on sweet or subacid varieties of summer and fall apples, although winter varieties do not entirely escape. A small amount of injury results from the egg laying of the flies. The flesh immediately surrounding the egg punctures sometimes fails to grow, causing dimplelike depressions in the surface.

CAUSE

The apple maggot or railroad worm is a footless white or cream-colored larva, usually about one third of an inch long when full grown. The adult form is a fly, somewhat smaller than a house fly, which emerges from the soil during late June, July, or early August, depending on the locality. The flies make tiny punctures in the skin of the fruit and place their eggs just underneath. The eggs have a short period of incubation, and in hot weather they hatch in from 4 to 6 days. The period spent by the maggot in the fruit varies greatly but may be as short as 2 weeks. When mature, the maggots leave the fruit, which by this time has fallen to the ground, and enter the soil, forming puparia which resemble grains of wheat. Within the puparia the insects transform to the adult stage and emerge the following summer or sometimes the second summer.

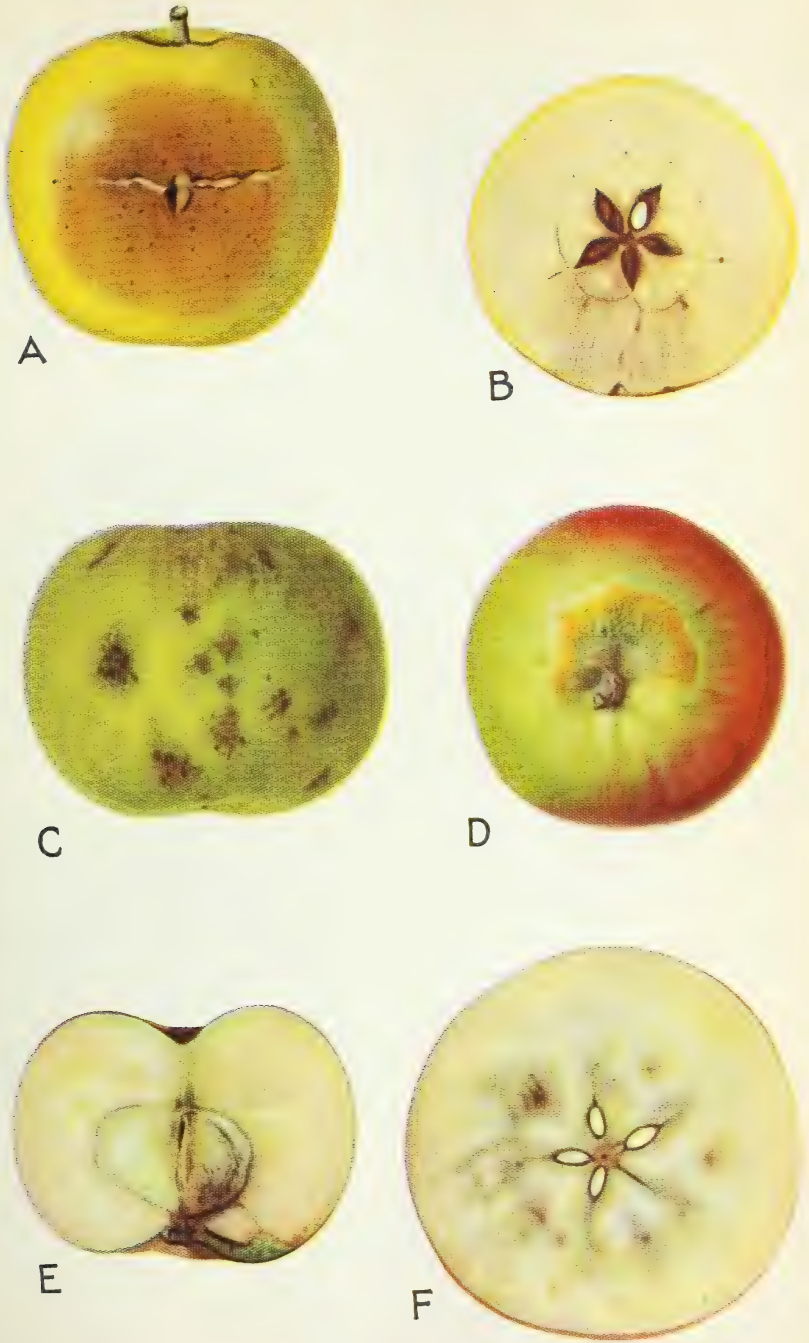
CONTROL MEASURES

Since much of the infested fruit comes to the ground as windfalls, and the maggots rarely leave until some time after the fruit has fallen, the collection and destruction of drop fruit will do much to control the pest. The benefits of this practice, however, are not evident until the following season.

Satisfactory control of the insect has also been obtained by spraying the trees with lead arsenate at the proper time in the summer, thus killing the adults before they lay their eggs. Usually two applications of lead arsenate at a strength of 1 pound in 50 gallons of water, with an interval of approximately 2 weeks between, have been sufficient. In view of increasing difficulty with spray residue, it is impossible at the present time to recommend this treatment, although with the use of effective washing machinery the satisfactory removal of the residue may be possible. Current recommendations of the Bureau of Entomology or of State experiment stations should be used as a guide in working out a control program.

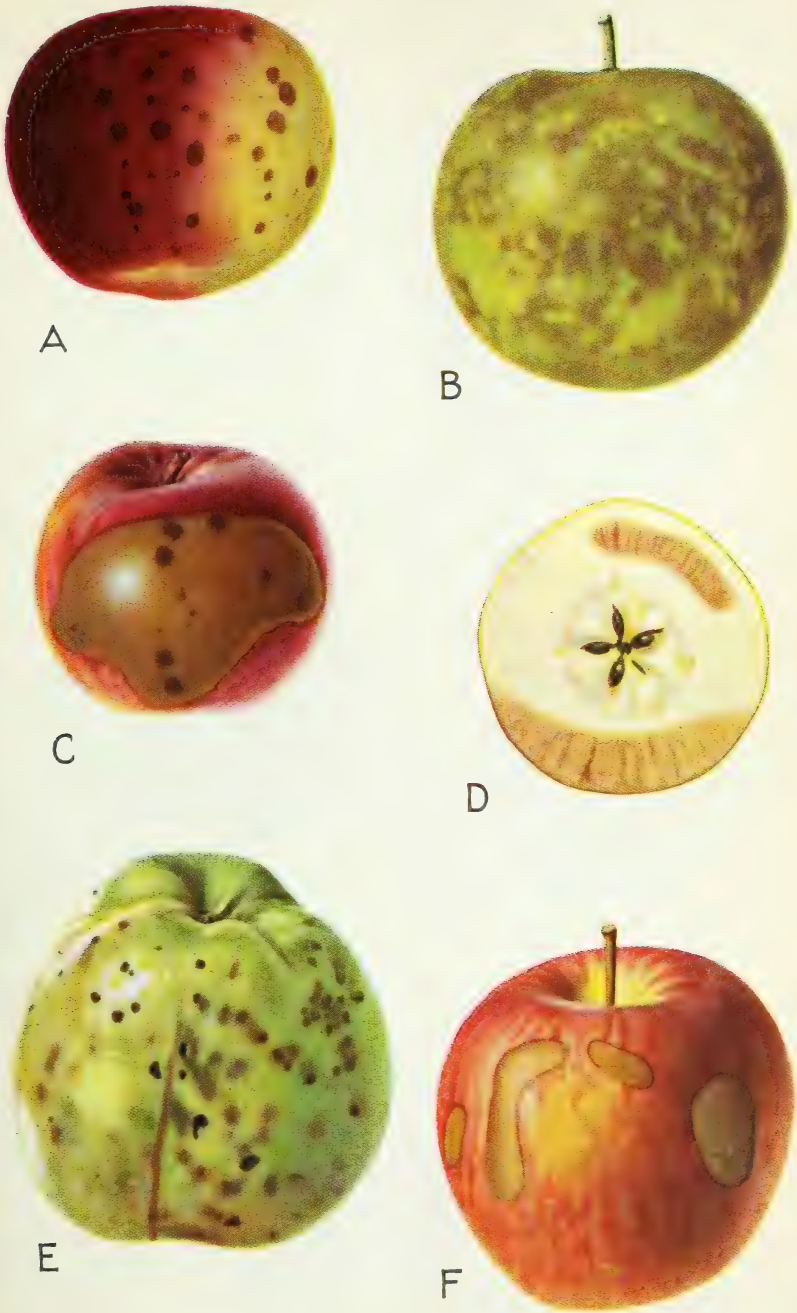
Recent experiments by the New Hampshire Agriculture Experiment Station [3] have shown that if infested fruits are held continuously at 32° F. for 1 month, practically all of the eggs and maggots are killed. With a longer period of exposure, this method of

[3] Personal communication from G. F. Potter to D. F. Fisher, 1932.



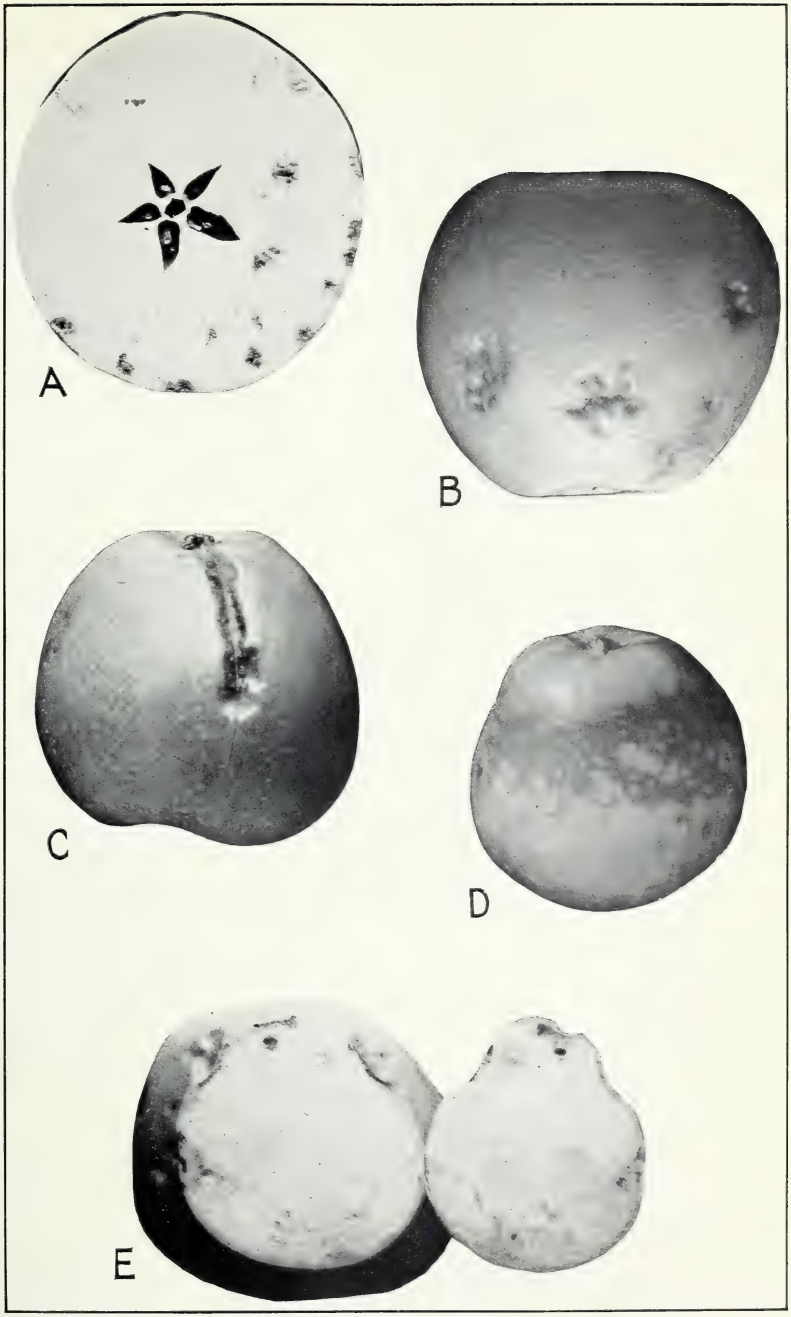
APPLE DISEASES

A, Phytophthora rot on Grimes Golden; B, Phytophthora rot on Grimes Golden (note indefinite edge of lesion); C, blotch on Oldenburg; D, cedar rust on Rome Beauty; E, cedar rust on York Imperial; F, quince rust on York Imperial ; very little injury apparent on the outside.



APPLE DISEASES

A, Jonathan spot on Jonathan; B, scald on Baldwin; C, soft scald on Winesap showing black spots caused by secondary fungus infection; D, soggy breakdown on Grimes Golden; E, bitter pit on Delicious (note two stages of the disease); F, soft scald on Rome Beauty.



APPLE DISEASES AND INJURY.

A, Bitter pit on Winter Banana; B, bitter pit on Winter Banana, outside view of coalescent type; C, bitter pit on Winter Banana; D, frost band on Stayman Winesap; E, bitter pit on Winter Banana, sectional view of coalescent type.

control promises to be of considerable importance in the handling of fruit to meet quarantine requirements relative to the shipment of infested fruit. (*4, 37, 38, 73, 74, 175, 184, 201.*)

BITTER PIT

Bitter pit occurs in all the important apple-growing regions of the world. In the United States it may be found on practically all varieties of apples but is of commercial importance on only a few of these. The Baldwin, Northern Spy, Rhode Island Greening, Grimes Golden, Tompkins King, Yellow Newtown, York Imperial, Ben Davis, Rome Beauty, Winter Banana, Stayman Winesap, Arkansas (Mammoth Black Twig), Arkansas Black, Delicious, and Gravenstein are among the more susceptible varieties.

In its usual form the disease is characterized by sunken spots about one sixteenth to one eighth of an inch in diameter, distributed over the blossom half of the apple. The spots resemble small bruises and are sometimes wrongly ascribed to hail injury. In the early stages they have a water-soaked appearance, but later they become more highly colored than the surrounding fruit surfaces, taking a deep-red color when on a blush area and retaining a bright green when on a green or a yellow fruit surface. They finally become brown or gray or sometimes black and are somewhat sunken (pl. 5, E). When the apple is peeled or cut, numerous spots and streaks of brown spongy tissue become evident just beneath the skin (pl. 6, A). These spots, though closely associated with the water-conducting system of the apple, are not confined to the region immediately beneath the skin, but may occur deep in the flesh. Contrary to the implication in the name bitter pit, affected tissues are rarely bitter.

On apples of the Yellow Newtown variety the spots may occur more on the cheek of the fruit than on the blossom end and are usually quite sharply sunken. In addition they are more nearly circular in outline than the common form described above, and the skin covering the depressed areas varies in color from gray to dark brown or black. Occasionally such spots have a more or less complete border of blackened skin that is only slightly depressed, if at all, below the level of the healthy skin.

Bitter-pit spots on the Winter Banana are frequently large and sharply sunken, and in such cases present the appearance of having been formed by the coalescence of several smaller spots, sometimes comprising areas half an inch to an inch long and of varying width (pl. 6, B, C, E).

The presence of high concentrations of certain salts in irrigation water is sometimes associated with and seems to be the cause of a condition in apple fruits that can hardly be distinguished from bitter pit. In the Pacific Northwest instances have been known where such spotting developed following the use of irrigation water containing a high percentage of Epsom salt (magnesium sulphate).

Bitter pit can be distinguished from fruit spot by the bruiselike appearance of the spots, the occurrence of the corky tissue beneath them, and the absence of the speckled appearance that is charac-

teristic of fruit spot. When confined to the surface region bitter pit is hard to distinguish from some forms of stigmonose, except for the fact that with the latter the individual corky areas are often larger than most bitter-pit spots, and minute punctures can sometimes be seen in the skin that covers them.

Bitter pit is a nonparasitic or physiological disease, and its occurrence is largely determined by orchard conditions. It is worse on fruit from young trees, especially if the crop is light, than on fruit from older trees, worse on large apples than on small ones, and worse on apples picked immature. It is greatly increased by heavy irrigation and heavy rainfall, particularly when these occur late in the growing season, and by heavy nitrogen fertilization. Conversely, everything that contributes to the stabilizing of moisture conditions in the soil and to an even, normal growth of the fruit throughout the season is of value in preventing the disease.

In recent investigations in the United States and Australia, evidence has been obtained that the disease is due to a killing of immature starch-filled tissues of rapidly growing apples or of fruit in storage, probably because of excessive transpiration that induces osmotic action between the starch-filled cells and those in which most, possibly all, of the starch has been changed to sugar. According to this explanation the starchy areas are killed by excessive desiccation. It should, therefore, be possible to reduce the amount of bitter pit by speeding up the rate of ripening. In a recent series of tests (*3*) it has been found that although the development of bitter pit is retarded by storage at 32° F., it will develop rapidly on immature fruit after removal from such storage. On fruit held continuously at 70° after harvest the disease made less development than on fruit held at lower temperatures, which did not permit as rapid ripening.

Bitter pit does not spread from one apple to another in transit or in storage, but under favorable conditions (see above) spots already present may enlarge and others may develop either on fruit affected when stored or on seemingly sound apples from the same orchard or similar orchard conditions. (*3*, *22*, *25*, *32*, *33*, *34*, *35*, *62*, *72*, *75*, *80*, *100*, *105*, *114*, *133*, *153*, *154*, *155*, *156*, *157*, *169*, *175*, *186*, *195*, *208*, *209*.)

BITTER ROT

(*Glomerella cingulata* (Ston.) Spauld. and Schrenk)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Bitter rot is of greatest importance on the apple, though it may occur on pear, peach, quince, and cherry. It is found in practically all apple-growing regions east of the Great Plains, but it is most common and most destructive in a strip of territory extending from Arkansas and southern Missouri eastward to North Carolina and Virginia. Even there it is irregular in occurrence, being worse in warm, wet weather than in dry and fairly cool weather.

The disease usually appears in the orchard in late June or early July but becomes most serious in August and September on well-developed fruit, hence the name " ripe rot " sometimes applied to it.

The most susceptible varieties are Yellow Newtown, Huntsman, Willowtwig, and Ben Davis. In Arkansas and southern Missouri, Jonathan and even Winesap are sometimes affected.

Bitter rot is characterized by brown, definitely limited spots varying in size from mere specks to lesions involving the whole side of an apple (pl. 1, C). In extreme cases the entire fruit may be rotted. Spots smaller than one eighth of an inch in diameter—not common on the market—usually occur as green or brown blister-like areas that are dry and firm. Larger spots are sunken and soft. Contrary to the implication in the name "bitter rot", the decayed flesh is not generally bitter. Spots half an inch in diameter or larger usually show spore masses that may or may not be arranged in concentric circles. Under orchard conditions these spore masses are at first pink or cream colored; eventually they become gray or almost black. In storage they may not show the pink color at any time. The color and arrangement of the spore masses serve to distinguish the disease from black rot, in which the pycnidia (spore-producing bodies) are always black and scattered irregularly over the diseased area. The alternating zones of light and dark brown so characteristic of black rot are rarely seen in bitter rot except in affected apples held in storage for some time.

CAUSAL FACTORS

The disease is spread by means of spores, which are produced in immense numbers during the growing season on bitter-rot mummies of the preceding year, on cankers caused by the bitter-rot fungus (*Glomerella cingulata*), and on blight, black rot, and other cankers at the edges of which the bitter-rot fungus has established itself. In warm wet weather the spores are washed down on the apples below and germinate there, producing fungus threads which enter the fruit and cause decay.

Bitter-rot cankers consist of sunken areas of dead bark, usually somewhat oval in outline, beneath which the wood is dead and dry (*191*). The dead bark adheres rather firmly to the wood and in older cankers frequently has a zoned appearance because of the development of cracks parallel to the edges of the canker. Often the canker is surrounded by a layer of callus, which prevents its further extension and eventually obliterates it entirely.

CONTROL MEASURES

Bitter rot is rarely seen on the market. It probably develops to some extent after picking on fruits already infected, if the temperature is not kept below 50° F. Apparently it does not spread from one fruit to another.

Control measures include frequent thorough spraying with 4-4-50 Bordeaux mixture, beginning about the middle of June, the removal of cankered limbs, the scraping and painting of cankers, and the removal of bitter-rot mummies. (*11*, *22*, *75*, *100*, *114*, *118*, *119*, *183*, *187*, *189*, *190*, *191*, *193*, *195*, *201*, *203*, *204*, *208*, *209*.)

BLACK ROT

(*Physalospora malorum* (Pk.) Shear)[4]

OCCURRENCE, SYMPTOMS, AND EFFECTS

Black rot is a disease of apples, pears, and quinces that is found in most of the producing sections of the United States east of the Rocky Mountains. Practically all varieties of pome fruits are susceptible, although the greatest losses usually occur on those ripening in the summer and fall.

Black rot is characterized in its early stages by brown rotten spots on any part of the apple. These spots vary greatly in size and are usually irregular in outline. Under field conditions they may show zones of different shades of brown, for which reason the disease is sometimes called ring rot (pl. 1, B). In late stages the spots enlarge, become black, and show numerous small black pimples scattered over the surface. In these pimples (pycnidia) are produced the spores which are the chief means by which the fungus is distributed and propagated. Apple flesh affected by the rot is always quite firm.

CAUSAL FACTORS

Black rot is caused by the fungus *Physalospora malorum.* Formerly it was known as *Sphaeropsis malorum*, but recent investigations have shown that this represents merely a particular stage in the life history of the fungus. Consequently the fungus is properly referred to under the name of its perfect stage, *Physalospora malorum.* The disease can be produced by spores of either stage. The Sphaeropsis stage, by far the more common of the two, is found on twigs, limbs, fruit, and leaves; the Physalospora stage has been found so far only on twigs.

The leaf spots appear first as minute purple specks, which slowly enlarge, turn yellowish brown, and eventually become more or less lobed because of secondary growth of the pathogene from one or more points. It is this lobing and the final grayish-brown color of the center of the spot that have given rise to the name "frog eye" sometimes used for these spots. There is occasional secondary infection and enlargement of such spots by a species of *Alternaria.*

The characteristics of cankers produced by the black-rot fungus are as follows: The affected bark is at first slightly sunken and reddish brown in color; later, as the spot enlarges, the bark becomes dark brown or almost black, and cracks appear over the affected area. Very often there is a crevice, a clear line of separation around the edge of the lesion; in old cankers the successive stages in their development are indicated by a series of concentric crevices, which give the canker an appearance somewhat like that described for "frog eye" of the leaves. Limbs are sometimes girdled and killed by the canker during the second or even during the first year; or infection may merely extend up and down the limb, eventually producing a diseased area 2 or 3 feet long or even longer, but not killing the limb until after 2 or 3 years. On old cankers, and especially around the edges, the outermost part of the bark frequently becomes loosened

[4] Syn., *Physalospora cydoniae* Am. Auct.

and curls up in thin papery brown flakes or rolls. During the first season, or sometimes not until the second season, cankered areas show numerous pycnidia (the spore-producing pustules of the fungus) like those already described on the fruit.

Under favorable temperature conditions, 50° F. or higher, rotting of the fruit takes place in the orchard, in transit, in storage, and on the market. It does not ordinarily spread from one fruit to another.

Ripe fruit is more likely to be attacked than green fruit. Infection may take place at injured places in the skin, such as worm holes, bruises, limb rubs, and hail injury, in all of which the rot develops freely if conditions are favorable, and finally involves the whole fruit. Infection may also follow spray or frost injury at the blossom end, producing what is known as blossom-end rot. The rot may develop steadily from the time of infection and finally involve the whole apple, or it may progress for a short time, then become quiescent, only to start up again when conditions are more favorable, as, for example, when the fruit is barreled and shipped to market without refrigeration.

CONTROL MEASURES

Cutting out diseased limbs and twigs and cleaning and painting the cankers gives fairly good control, but only in proportion to the thoroughness with which it is done. The leaf spot can usually be controlled by the sprayings recommended for apple scab. Control of the fruit rot depends primarily on the elimination of cankers from the trees, the prevention of mechanical injuries to the fruit, and the maintenance of temperatures in storage and in transit that are unfavorable to the growth of the fungus. (*17*, *22*, *46*, *53*, *100*, *110*, *111*, *112*, *113*, *114*, *195*, *208*, *209*, *221*, *222*, *242*.)

BLOTCH

(*Phyllosticta solitaria* Ell. and Ev.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Blotch occurs in the territory extending west from southern New York to southern Iowa and South Dakota and south to Georgia and Texas. It is most common and most destructive in Kansas, Arkansas, and the southern portions of Missouri, Indiana, Illinois, and Ohio. The most susceptible varieties of commercial importance are Ben Davis, Northwestern Greening, Missouri Pippin, Oldenburg (Duchess of Oldenburg), and Wagener.

Blotch spots on the fruit are characterized by fan-shaped areas with fringed margins grouped around a common center, the diameter of the spots varying from one fourth to one half inch or more (pl. 4, C). The spots are light brown and superficial at first but later become nearly black and markedly sunken; the small black pycnidia (fruiting bodies) begin to appear within a few days after the blotch spot becomes visible. On Ben Davis and Missouri Pippin and sometimes on other varieties cracks occur in the older spots that often intersect in the form of a cross or a Y.

Most of the damage to fruit occurs late in June, the particular time varying somewhat with the variety and with the weather during

the growing season. Much of the diseased fruit drops before picking time, but that which arrives on the market suffers seriously from the disfiguring effect of the blotch spots and occasionally also from rots occurring as secondary infection by other fungi. Blue mold and the black-rot fungus are most commonly found associated with blotch in this way. On the market, blotch causes more loss than bitter rot and less than scab, yet the fungus develops and spreads very little, if at all, in transit and storage.

CAUSAL FACTORS

Blotch is caused by the fungus *Phyllosticta solitaria*, which attacks the leaves, fruit spurs, and twigs of the apple. The latter two are the sources from which infection spreads in the spring to other parts of the tree. Blotch spots on the fruit have already been described. On the leaves the disease appears as small, nearly white spots on the blades, and as dark, sunken, oval areas on the midribs and leaf stems.

During the first year after infection occurs on the twigs and fruit spurs, blotch occurs as black blisterlike spots. During the second year the spots assume a light tan color in the older or central portion, with a dark border denoting the extent of the second year's growth. Beginning with the third year the cankers appear as irregularly roughened areas resulting from a gradual sloughing of the dead parts by growth of the bark beneath them.

CONTROL MEASURES

Blotch can be controlled by spraying three times at 3-week intervals, beginning about 3 weeks after the petals fall. In regions where the disease has not been destructive, lime-sulphur is recommended for the first application and Bordeaux mixture for the later ones, in order to avoid spray injury to the fruit. Where the attack is severe or likely to be so, Bordeaux mixture should be used in all three applications. Spraying for blotch may well be combined with that for bitter rot. (*10*, *11*, *22*, *75*, *77*, *78*, *79*, *87*, *100*, *114*, *134*, *145*, *183*, *188*, *195*, *206*, *207*, *208*, *209*.)

BLUE-MOLD ROT

(*Penicillium expansum* (Lk.) ex Thom)

Blue-mold rot is the most common and usually the most destructive of all the rots found on apples, pears, and quinces in transit, in storage, or on the market. It occurs on all varieties of these fruits from all parts of the country.

The rot appears as soft, watery spots of a light brown to pale straw color, which show all possible variations in size and may occur on any part of the fruit. The spots are shallow at first, but extend deeper very rapidly, in fact, just about as rapidly as they increase in diameter on the surface, so that by the time the rot reaches the core it has involved a third or more of the fruit. Whether or not a surface growth of blue mold develops will depend very largely on temperature and moisture conditions and very little on

the size of the spot. In dry, cool air the growth rarely appears, even when the fruit is totally decayed. In air that is moist and warm the growth is almost sure to appear on spots of any size. Usually small tufts or bunches of fungus spores appear on the surface. These are white at first and bluish green later and look very much like minute bundles of bound grain (pl. 1, A). The blue-green color is due to production of spores. In all the pome fruits a musty odor can be detected when the rot becomes well advanced and spore production is heavy. The decayed flesh also has a musty taste.

CAUSAL FACTORS

Blue mold (*Penicillium expansum*) sometimes produces a superficial growth where it is not causing rot; but where rot exists the fungus can be found in the rotted tissues, even in the smallest spots; later on it may become evident externally in the form and color already described.

Blue-mold rot is not important as a field disease. Under conditions of abundant rainfall and summer or early fall temperatures it may occur on fruits fallen to the ground or on mashed or overripe specimens around the packing house, where it becomes important as a source of infection. It is almost never found on fruits hanging on the tree, unless they have been injured by insects, hail, or other agencies that produce skin breaks.

Most of the damage from this rot takes place in transit and storage, although even here the occurrence of such damage is no proof that the fruit was generally diseased when it left the packing house. There may have been a few slightly but visibly rotted fruits and a few in which the rot existed but not at such a stage that it was discernible. It is certain, however, that despite careful handling methods and packing-house sanitation (p. 3) most if not all of the fruit bore blue-mold spores on its surface when it was packed; consequently, if conditions in transit or storage were favorable, the rotten spots already present, whether visible or not, became larger and new ones could be formed by the germination of spores lodged on the fruit.

It was thought until recently that blue mold is unable to penetrate the unbroken skin of apples. Investigations in the Pacific Northwest (*6*) have indicated, however, that the fungus is able to enter apples through lenticels and that lenticel infection may be responsible for a large part of the average annual loss from blue-mold rot. There is evidence that infection can occur through only a few of the lenticels on apples. Nothing is known of the factors that tend to increase the number of infectible lenticels, but the possibility that such lenticels may occur makes it highly important that harvesting, cleaning, and packing methods be such as will reduce the spore load on the fruit.

Conditions that favor the development and spread of blue-mold rot in transit and storage are moisture, moderately high temperature, and skin breaks and lenticels through which the fungus can enter. Moisture may be present on fruit picked during times of rain or heavy dew or on fruit not thoroughly dried after washing; it may also condense on fruit because of a damp atmosphere in a storage

room or a car and fluctuation in car or storage temperature. Skin breaks may result from careless handling prior to loading, from rough handling in transit, or from shifting and breakage resulting from improper stowage of the load.

At 50° F. or below, the fungus is not likely to cause rot at new places, although if already established in the fruit it can continue to grow and cause rot. Growth proceeds more and more slowly, of course, as the temperature is lowered, but is not entirely checked, even at 32°.

CONTROL MEASURES

The most important factors in the control of the blue-mold rot are careful handling and prompt cold storage. Fruit intended for immediate shipment should be precooled if possible, and methods that hasten cooling in transit should be used. Special emphasis should be placed on careful handling and packing-house sanitation, in order to prevent skin breaks and keep the fruit as free as possible of fungus spores.

Delay in cooling, caused either by failure to store promptly, by belated icing of the cars, or by the loading of warm fruit, gives opportunity for the rot to develop, and so increases the probability of loss. Delay in moving the car also increases this probability by giving the fungus a longer time in which to work. (*6*, *7*, *22*, *59*, *62*, *80*, *98*, *100*, *101*, *114*, *135*, *195*.)

BOXWOOD SCALD

Boxwood scald is found when apples are packed in contact with box material made of Douglas fir (*Pseudotsuga mucronata* (Raf.) Sudw.) and has been observed more frequently with veneered than with sawed material. The injury is usually circular in outline, dark brown in color, and bears some resemblance to newly produced sun scald. Occasionally the browning occurs in the form of streaks. It is due to toxic terpene materials contained in fir wood. These are water soluble, and consequently the injury is most severe when the apples or boxes are wet when packed or when they become wet after packing.

The injury will develop on an area lying against a fir board, even though lining and wrapping paper are between the board and the fruit.

Boxwood scald can be avoided by using some other wood than Douglas fir for box material (*65*).

BROWN ROT

(*Sclerotinia cinerea* (Bon.) Schroet.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Brown rot attacks apples, pears, and quinces in practically all producing sections of the eastern United States and is more common on early than on late varieties. It has also been found on Gravenstein and other fall varieties in the humid sections of Washington and Oregon. The rot seldom causes serious loss.

Brown rot occurs almost always as a rather soft but not mushy decay, in spots which are brown at first but which as they enlarge, ultimately involving the whole fruit, become black all over or in irregular blotches (pl. 1, D). In a moist, warm atmosphere the fungus appears on the outside as grayish spore-bearing tufts varying in size from mere pin points to patches half an inch or more across. Under dry cool conditions the tufts are rarely seen.

Brown rot often resembles black rot so closely that positive diagnosis is difficult. There are some points of difference, however, which should be kept in mind. Apples in the early stages of brown rot frequently show circular black spots about one eighth of an inch across, each with a lenticel at the center, scattered over the otherwise uniformly brown, rotted area (pl. 1, D). Apples in the early stages of black rot have either a solid reddish-brown color or alternating zones of light and dark brown. As the two diseases develop, brown rot becomes darker, sometimes almost black all over, and the characteristic gray fungous tufts appear; black rot becomes merely darker brown and shows numerous small black pycnidia (fruiting bodies) scattered over the rotted area. Apples affected with brown rot show some degree of blackening at an earlier stage, and they shrivel sooner than do those affected with black rot; in both rots a black, wrinkled mummy is the final result. Black rot is much firmer than brown rot; in fact, it is the firmest of all apple rots, with the possible exception of Phytophthora rot.

CAUSAL FACTORS

Brown rot of apples, pears, and quinces is caused by the same fungus that causes brown rot of stone fruits. It is sometimes found on apples while they are still on the tree, especially in orchards where stone-fruit trees have been planted as fillers, but usually does not attack them until after they are harvested. So far as known, the rot attacks pears and quinces only during the process of marketing.

CONTROL

Brown rot is checked by low temperature, but more so in very early stages than after it becomes well established in the fruit. Like most other apple rots, therefore, it can be controlled fairly well after harvest by placing the fruit under refrigeration as soon as possible. Control in the orchard can usually be obtained by the use of sulphur sprays. (*22*, *97*, *100*, *114*, *195*.)

BRUISES

BRUISES BEFORE HARVEST

Bruises produced before the apples are mature, by thinning shears, ladders, orchard machinery, harness, or by the rubbing of fruit against limbs or twigs, are usually hard and dry compared with other types described below and often resemble drought spot in the ripe fruit. They can sometimes be distinguished from drought spot by a more distinct margin, a more irregular shape, and sometimes by a sponginess likely to be absent in drought spot.

PACKING BRUISES

When apples are handled roughly during the picking and packing process, bruises are produced that are easily recognized afterward as having been produced by such handling. These bruises are usually not large, and the skin covering them is only slightly discolored, if at all. The bruised flesh becomes brownish in color and in most instances shows lines of fracture that are roughly parallel to or curved slightly away from the surface of the fruit (pl. 11, C, *b*, *c*). Except for a few days after the time when the bruising takes place, the injured flesh is dry and corky.

The bruises produced when the cover of the container is forced into place over a full, tight pack may be decidedly flattened and an inch or more in diameter, especially in apples next to the lid of a basket or box or at the tail end of barrels. Farther down in the barrel, or away from the sides of a basket or box, the bruises are likely to be concave, particularly if the fruit is ripe and soft, because of the forcing of one apple against and into another. The flesh around the outer edge of the bruised region in ripe apples when observed in cross section may also show a water-soaked, glassy condition beyond which is a zone of unfractured brown flesh in which delicate brown lines (small vascular bundles) can be seen.

In apples next to the lid, especially at the tail end of barrels, the bruised area seen in cross section is often conical in shape and extends deep into the flesh, sometimes clear to the core. At such places the flesh inward from the skin about a quarter of an inch is brown and that nearer the core has the water-soaked appearance mentioned above.

TRANSIT BRUISES

There is also another kind of bruising that occurs in boxed apples in transit. The injury is usually found only in the apples that are at the lower side of the bottom layer of boxes in the car and for this reason is frequently thought to have been caused by freezing. It is more common during the winter months than during the fall and spring, but nevertheless has been found in boxed apples shipped in the fall before freezing weather has occurred either in the producing regions or anywhere along the routes taken by the shipments. The injury has also been found so late in the spring that there was no possibility of the fruit having been exposed to freezing weather in transit.

The following are the characteristics of this transit bruising: There are flat, bruised areas on the sides of the apples that were in contact with the lower side of the box as the latter lay in the car. The bruised spots have a water-soaked, darkened appearance, are generally quite firm, and may be an inch or more in diameter (pl. 11, A). Occasionally the skin covering them is discolored in spots or streaks. In cross section there is usually a water-soaked, glassy, wedge-shaped area extending from the skin toward the center of the apple (pl. 11, B, C, *a*, D). It may be shallow or it may extend quite to the core. In some instances the inner edge of this area appears as a fairly smooth curve, convex toward the core; in others it is broken by strands or rays having the water-soaked appearance just mentioned and extending radially for as much as three fourths

of an inch beyond the main affected area. Small water-soaked patches or streaks are sometimes seen also underneath bruises produced by the pressure of one apple against another, as shown in plate 11, C, *b*, *c*.

Recent investigations have shown that bruises like those just described can be produced by subjecting apples to a jolting similar to that received while they are in transit by rail. Glassy water-soaked bruises are not necessarily a sign of freezing injury (p. 24); neither are wedge-shaped injured areas that extend to the core, nor brown bruised spots under the skin, in which vascular browning has occurred. All of these can be produced by such jolting and pressure as apples are subjected to while in transit in railroad cars (pl. 11, F).

CONTROL MEASURES

Packing bruises can be largely avoided by careful handling methods. The only successful method known at present for the prevention of transit bruises is to place cushioning material, such as corrugated paper liners, between the apples and the sides of the boxes, to absorb the vibrations that cause the bruising. (*198.*)

BULLSEYE ROTS

OCCURRENCE, SYMPTOMS, AND EFFECTS

The term bullseye rot is applied to a form of decay found in apples from the Pacific Northwest, including British Columbia. The decay occurs as circular spots having pale centers and darker brown borders. In reality there are six distinct rots that have this bullseye appearance, but they resemble one another so closely that they cannot be distinguished with certainty except by laboratory study. These rots are (1) perennial canker, caused by *Gloeosporium perennans* Zeller and Childs; (2) northwestern anthracnose, caused by *Neofabraea malicorticis* (Cordley) Jackson; (3) Fusarium rot, caused by a species of *Fusarium;* (4) fisheye rot, caused by *Corticium centrifugum* (Lév.) Bres.; (5) Ramularia rot, caused by *Ramularia magnusiana* (Sacc.) Lind.; and (6) Sporotrichum rot, caused by *Sporotrichum malorum* Kidd and Beaumont.

The rots caused by the perennial canker fungus and *Corticium* (fisheye rot) are more or less prevalent in apples from all of the irrigated districts east of the Cascade Mountains. Fisheye rot also occurs on apples from producing sections of the eastern United States. Northwestern anthracnose and the particular Fusarium rot of this type occur on fruit from the more humid regions west of the Cascades but have not been found in the irrigated regions east of those mountains.

These bullseye rots resemble one another closely, as already noted, but there are several characteristics that can be used to help in diagnosis. The first of these is the presence or absence of a fuzzy growth protruding upward with the spore masses from the surface of decayed spots. If the growth is present the rot is probably due to the perennial-canker fungus (pl. 2, A, E; C and D illustrate perennial canker rot not showing mycelium). If the spore masses are cream colored, occur in rather definite rings, and are not accompanied by

surface mycelium, northwestern anthracnose is indicated. If yellowish spore masses occur and the rotten spots are small and rather numerous, the causal fungus is probably *Fusarium*. Fisheye rot usually carries a very downy surface mycelium without spores, and the affected flesh has a tough, stringy or spongy texture. Spots of this rot are more sunken than those of the other rots here under discussion (pl. 2, B).

Spots caused by *Sporotrichum* are oval or circular in outline, usually less than an inch in diameter and only slightly depressed. The affected tissues are watery but firm and can readily be separated from the surrounding healthy flesh. No surface mycelium is produced except under very moist conditions. There is nothing particularly noteworthy about the Ramularia rot except that affected spots have the general bullseye appearance already described.

The northwestern anthracnose fungus and the perennial canker fungus produce cankers on twigs and branches from which spores may be washed by rain to apples growing beneath the cankers. The other fungi are not known to have any parasitic stage other than that on the fruit, but it seems certain that 2 or 3 of them are able to develop to some extent on dead wood, bark, twigs, or leaves of the apple or even on other plant material common in orchards.

Of these six rots, the most common on the market are perennial canker, anthracnose, and fisheye rots. All of these are able to develop at 32° F. but do so rather slowly and are not often found in stored lots until January or February following harvest. There is no evidence that they can spread in transit or storage. The other four develop slowly but do not spread at cold-storage temperatures, and do not usually become of commercial importance in stored lots until rather late in the season. (*29*, *30*.)

CONTROL MEASURES

Careful spraying with Bordeaux mixture is the best means of controlling northwestern anthracnose in the orchard. Such spraying coats the limbs with a substance toxic to the fungus and in most cases gives a protection that means for the following year (1) more vigorous trees, (2) fewer cankers, and (3) less rot on the fruit. One application should be made as soon as possible after the fruit is picked, and another 2 or 3 weeks later; in cases of severe attack it is advisable to make one application 2 or 3 weeks before the fruit is picked.

Removal of limbs affected with anthracnose and the excision and painting of cankers are helpful measures, but should never be considered as more than merely supplementary to spraying. When cankers are cut out the material removed should be destroyed and the wound disinfected and coated with a waterproof elastic wound dressing.

For the control of perennial canker rot a thorough application of Bordeaux mixture, 4-4-50, is advised. Ordinarily this should be applied about September 10, or before the fall rainy season starts. Spray residue from Bordeaux mixture forms a heavy coating on the apples which interferes with the development of normal coloring of the fruit, hence it is desirable to delay the spraying as late as is compatible with satisfactory control. Since the tree cankers are the

source of fruit infection, their removal in pruning or special surgical operations has an important bearing on the control of the fruit rot.

The fisheye rot caused by *Corticium centrifugum* is most common on windfalls, doubtless because of its presence on decaying cover-crop material under the trees. Consequently apples that have dropped to the ground should never be packed with fruit for storage even when they are apparently uninjured, as is sometimes the case in orchards having a heavy cover crop.

No methods of control are known for the other three rots. (*22*, *41*, *62*, *99*, *100*, *101*, *114*, *186*, *194*, *195*, *243*, *244*.)

CHEMICAL INJURIES

INJURY BY SALT, LIME, OR FERTILIZERS

When railroad cars are used for the shipment of salted hides, salt, fertilizer, or lime, either in bags or in barrels, there is usually some wastage onto the car floor and walls. If such cars are afterward used for the shipment of fruit in bulk, there is bound to be, at various places, a close contact under pressure between the spilled chemical and the fruit. When this occurs, as observed most commonly with apples, the fruits immediately in contact with the chemical become noticeably flattened where they touch it, and the skin and underlying flesh show a brown leathery condition. If salt is the chemical concerned, it can often be detected by tasting the injured flesh. Fertilizers and lime are less easily detected in this way, so that when injury is found and either of these substances is suspected to be the cause, diagnosis will have to depend chiefly on whether or not they can actually be found on the car floor and walls. Injury comes about only where the fruit lies in contact with the chemical, and it is usually more severe in the layer next to the floor than in that next to the wall. It is due apparently to the forcing of the fruit into or against the chemical by the weight of the overlying load, combined with the rubbing that results from the constant jolting and shifting about of the load in the moving car.

INJURY BY HYDROCHLORIC ACID

Injury to apples caused by hydrochloric acid used in washing treatments appears typically as a bleaching of the skin. It usually appears within a day or two after washing. At first the color seems merely to fade into the flesh and the skin softens, but later the skin may crack through the center of the spots and become dry and papery. With age the spots become depressed, and sometimes the presence of dissolved arsenic in the acid washing solution causes them to turn black. The appearance and severity varies somewhat with different varieties, and sometimes the presence of a few tiny black freckles found at lenticels on stored fruit, especially Winesap and Arkansas Black, may be the only indication of acid injury. Such spots might easily be mistaken for Jonathan spot.

Acid injury is sometimes localized in the stem or calyx regions or at points where the apple has remained in contact with other objects; but usually the injured areas are scattered irregularly over the apple, marking places where drops of acid washing solution evaporated. Where drops of this solution concentrate to an in-

jurious strength through evaporation, the outline of the affected area is usually circular (pl. 12, A, B), but where acid accumulates between an apple and some other object in contact with it the outline may be quite irregular. This injury bears a close resemblance to that sometimes found on apples when sulphur dioxide escapes from refrigerating systems. In the latter case, however, the apples are usually more generally speckled at lenticels and the margins of the bleached areas become black with age, while the spot itself may become faintly zoned in appearance.

Acid injury can be prevented by careful attention to instructions given in Farmers' Bulletin 1687 (*51*) and Technical Bulletin 245 (*70*) for the use of hydrochloric acid solutions for washing apples. Of especial importance in preventing acid injury is thorough rinsing of the fruit after it passes through the washing solution. (*50*, *68*, *69*, *70*.)

INJURY BY ALKALINE SOLVENTS

Although hydrochloric acid is the solvent commonly used for the removal of arsenical spray residue, a number of alkaline materials, including solutions or mixtures of sodium hydroxide, sodium carbonate, trisodium phosphate, borax, sodium silicate, and other substances are also employed. These solvents are sometimes used at a temperature of 100° F. or higher.

Arsenical injury occurs somewhat more commonly on apples washed in alkaline solvents than on those washed in hydrochloric acid. Because the alkaline solvents are much more difficult to rinse off than is the hydrochloric-acid solution, apples washed in the former often retain some of the solvent in the calyx cavity, where it continues to react with residual lead arsenate, forming the injurious soluble arsenic.

Occasionally the alkaline solution itself causes chemical injury. Such injury is usually localized around the stem or calyx but is sometimes found at the lenticels as well (pl. 12, E). It is shown by the effect on the skin, which becomes dry and papery, tightly stretched, but seldom cracked, as in the case of hydrochloric-acid injury, and is often torn loose from the underlying fleshy tissues. The color is yellowish or brownish yellow, except when a considerable quantity of arsenic is present, in which case the color becomes dark brown or black. (*68*, *69*, *70*.)

INJURY BY SOLUBLE ARSENIC

The injury that has sometimes been called calyx scald or water scald should be designated as arsenical injury. It occurs as depressed black or brownish spots in the calyx cavity, often encircling the calyx, or occasionally it is found in the stem basin. Sometimes the flesh is killed to a depth of half an inch or more. When the skin is killed the apple is readily attacked by decay fungi (pl. 12, C, D).

Arsenical injury on harvested fruit may be produced in several ways: (1) By allowing heavily sprayed fruit to become or remain wet for a period of several hours before the spray residue is removed. In this case it is due to soluble arsenic in the spray residue and may occur on the trees before picking. (2) By the prolonged use of

washing solutions in which dissolved arsenic has accumulated in toxic amounts. (3) By faulty rinsing facilities which permit some of the solvent to remain in the calyx region, there to continue solvent action on arsenical spray residue not removed in the washing treatment.

Arsenical injury may appear within a week or two after washing but usually requires several weeks to develop on all of the apples that may become affected in any lot. It seldom if ever occurs on the cheek of the fruit. Chemical injuries appearing on the cheek of washed apples are usually due to the solvents employed for spray removal. Dissolved arsenic present in washing solutions often causes such injured areas to turn black, but the primary cause of damage in those areas is not arsenic. (*68*, *69*, *70*, *159*.)

INJURY BY SULPHUR DIOXIDE

Apples are sometimes injured by accidental exposure to sulphur dioxide escaping from a refrigerating apparatus in which this gas is used as the refrigerant. No statement can be made as to the effect of definite percentages of sulphur dioxide. It is known, however, that if only a small quantity of the gas is present in a chamber containing apples an injury may be produced, usually consisting of decolorized, whitish, papery spots at the lenticels. If the concentration of the gas is high and remains so for several days, all of the skin of fruits exposed to it becomes decolorized on yellow apples, or uniformly some tint of red if the apple was originally red; the flesh is softened and rubbery and usually has a strong sulphurous and nauseating flavor.

CODLING-MOTH INJURY

(*Carpocapsa pomonella* L.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Wormy fruit, injured by the larvae of the codling moth, may be found on the market in apples and pears from all producing areas of the United States, the proportion of injured fruit varying with the locality in which the fruit is grown, and with the care under which the fruit is grown and graded.

The typical wormy apple (pl. 20, B) is too well known to require an extended description. The worm may enter at the calyx, at the side, or at the stem end of the fruit, and it tunnels more or less directly to the core. The area surrounding the core becomes a mass of dark-colored frass and fragments of fruit tissue. In leaving the fruit, the larva usually goes directly from the core to the side. The tunnels permit the entrance of the blue mold, *Alternaria*, the black-rot fungus, and other rot-producing fungi. A second type of damage, known as sting injury or "worm sting", consists of small discolored, hardened, often depressed spots, usually with a tiny hole at the center (pl. 19, B). These are caused by the larvae that have consumed a fatal dose of poison but have managed to burrow a short distance into the fruit before death.

CAUSE

The worm, or larva, causing worminess in apples is about three fourths of an inch in length when full grown, and is cream-white to pink-white in color, with a dark-brown head. The insect hibernates in the larval stage in cocoons in crevices in the bark, in trash on the ground, in orchard lug boxes, and in packing sheds. The adults begin to emerge during or shortly after the blooming period. The moths have a wing expanse of one half to three fourths of an inch; they are brownish gray in color, with a dark-brown spot, crossed by two golden bars, at the tip of each fore wing.

CONTROL MEASURES

In most regions the codling moth may be satisfactorily controlled by spraying with lead arsenate, the exact number of applications varying with the locality. The presence of excessive quantities of lead or arsenic on marketed fruits, however, constitutes a potential danger to human health. Because of this spray-residue problem, intensive investigations are now under way. These may result in radical changes in the present codling-moth-control programs. On account of this factor, and because spray programs vary so much as between different localities, no detailed schedules will be given here. In planning a season's codling-moth-control operations, growers should therefore be guided by the current recommendations issued by State experiment stations or by the United States Department of Agriculture.

A great deal can be done by a number of other practices formerly considered supplemental to spraying. Important among these is the use of trap bands, by means of which the grower can capture and destroy from 30 to 50 percent of the worms in the orchard. A recent development has been the chemically treated bands, which are automatic in operation, killing the worms which enter them. If banding is to be effective, the trunk and larger branches of the tree should be thoroughly scraped, and the loose flakes of bark caught on a canvas and destroyed, thus eliminating the places normally preferred for cocooning. This forces the worms to go into trap bands. Packing sheds should be kept closed or well screened wherever possible during the period when the moths are emerging, in order that the moths may be prevented from reaching the orchard. Orchard lug boxes and other containers should either be treated with hot water or otherwise to destroy worms which have cocooned in them, or should be kept during spring and early summer in a tightly closed storage space. (*73; 74; 164; 165; 166; 183, p. 36–37; 184; 194; 201; 211; 213; 214; 215; 216; 233; 234.*)

CORE ROT

(*Penicillium, Alternaria, Rhizopus, Physalospora,* and *Fusarium*)

Apples are sometimes observed which, though sound so far as external appearances indicate, are decayed at the core. The condition is due to infection with some of the common rot fungi, following codling-moth injury, or less frequently following injury by the lesser apple worm. It sometimes follows cracking at the blossom end, and

also the condition seen occasionally in Delicious, Grimes Golden, and a few other varieties in which open calyx tubes furnish a passageway from the outside into the seed cavities. During recent years it has been found more commonly on apples washed by submersion methods that permit infected washing solutions to penetrate into the core.

Core rot is of very little commercial importance. (*88*, *89*, *90*, *91*, *142*, *152*, *170*, *225*.)

CORK

Cork spots are located in the flesh of the apple, often in close association with the strands or bundles that conduct food and water through the fruit. Seen in cross section they appear as patches of dead brown tissue much larger than either bitter pit or stigmonose and occur much deeper in the tissues than drought spot (pl. 9, F). When they occur near the core and nowhere else, the only external signs that they exist are a bumpy surface contour and a rubbery feel when the fruit is compressed in the hand. When they occur in the outer part of the flesh, depressions are found over the dead spot and the apple is more or less roughened or corrugated. Affected apples ripen prematurely, but their keeping quality is not otherwise altered.

Diseases of the cork type are widely distributed. They have been reported from all the important apple districts of Washington and Oregon, from British Columbia, from New York, and from various apple districts of Virginia and West Virginia. The trouble known in Virginia as "York spot" and in California as "hollow apple" seems to be very closely related to cork. A disease apparently identical with cork has also been reported from Australia under the name of "crinkle."

Apples affected with cork are sometimes also affected with a condition known as "apple blister", apparently due to the same conditions that produce cork but active earlier in the season. The first stage of apple blister consists of raised brown or reddish spots on the skin of the apple; later on, as the apple develops, the blisters crack and scale off, exposing a rough, corky layer that has formed beneath.

York spot has been found to occur almost exclusively on apples well exposed to sunlight, always on the blush side, and always on fruit surfaces that would receive the oblique rather than the direct rays of light. The spots are similar in appearance to cork, but instead of being scattered throughout the apple are often located in a crescent-shaped line at the edge of the blush surface. Occasionally there is a definite ring of them almost entirely surrounding the blush surface. The skin of the apple is always normal and the corky tissue beneath is usually indicated by surface depressions. As suggested by its name, this type of injury is very common on York Imperial apples.

Cork, blister, and other similar forms of injury are all apparently due to physiological drought, though in general to drought less severe and more long-continued than that known to cause typical drought spot (p. 24). These injuries seem to occur most commonly on soils lacking humus and not retentive of moisture. York spot is apparently due to the combined effects of drought, sunlight, and high

temperature in the orchard. Although these forms of injury cause appreciable loss at times in the orchard, they are only occasionally found on the market.

Control of the diseases depends, obviously, on preventing drought conditions whenever possible and maintaining a healthy, vigorous root system, capable of supplying the moisture required by the tree. (*25*, *100*, *150*.)

DROUGHT SPOT

Drought spot is known to occur in many parts of the United States, but has been seen on the market chiefly on apples from the Northwest. The varieties most often affected are Winesap, Stayman Winesap, and Delicious. Ben Davis, White Pearmain, and certain other varieties, if exposed to the same drought conditions, will wilt or shrivel instead of becoming affected with drought spot.

The disease is exhibited in oblong to roughly circular areas, usually not more than a fourth of an inch across and always somewhat sunken below the surrounding fruit surface (pl. 7, A, E). The skin color in these areas either is not changed or is somewhat darker than that normal for the variety. Browning may occur beneath the skin but rarely extends to a depth of more than a sixteenth of an inch; occasionally brown streaks follow the water-conducting vessels deeper into the pulp (pl. 5, D).

In early stages (practically never seen on the market) the disease appears as large, irregular, water-soaked spots that often have a reddish margin and are usually covered with drops of oozing sap which is sweetish, yellow, and sticky at first, later becoming hard and brittle.

Drought spots may occur on any part of the fruit surface; they differ in that respect from bitter pit, which usually occurs on the blossom half of the fruit, and from hail injury, which is almost always restricted to one side or one end. The roughly circular outline of drought spots distinguishes them from the creases produced by the pressure of twigs or small limbs while the fruit is developing.

The disease is caused by sudden and severe drought and obviously is to be controlled by preventing the occurrence of drought conditions whenever possible. (*22*, *25*, *100*, *150*, *195*.)

FLYSPECK

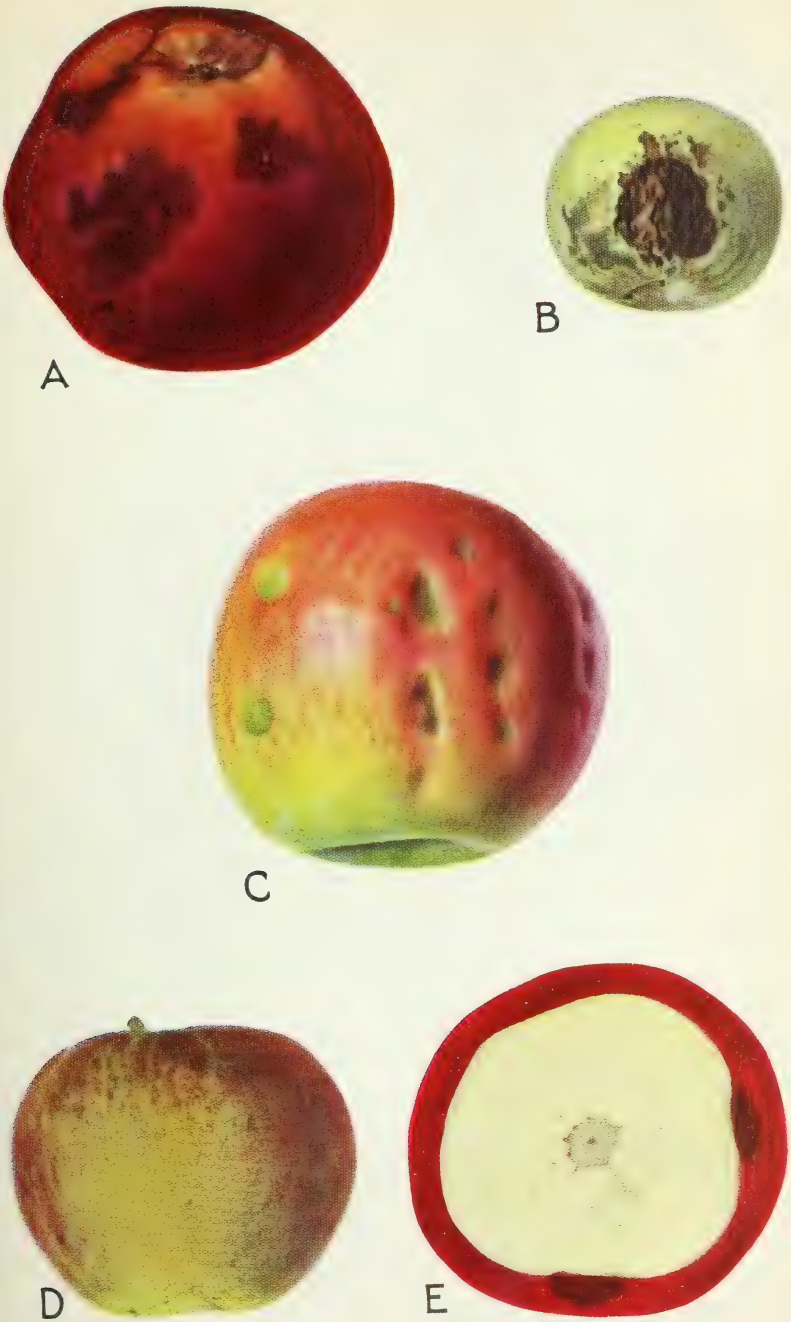
(*Leptothyrium pomi* (Mont. and Fr.) Sacc.)

Flyspeck (pl. 3, C) is well described by its name. The specks occur in areas usually not more than half an inch in diameter and are as easily scraped off as sooty blotch. The two diseases are usually associated, but are caused by different fungi.

Flyspeck is of importance on the market only because of its effect on the appearance of the fruit. It can be controlled by the treatment recommended for scab. (*100*, *114*, *161*, *183*.)

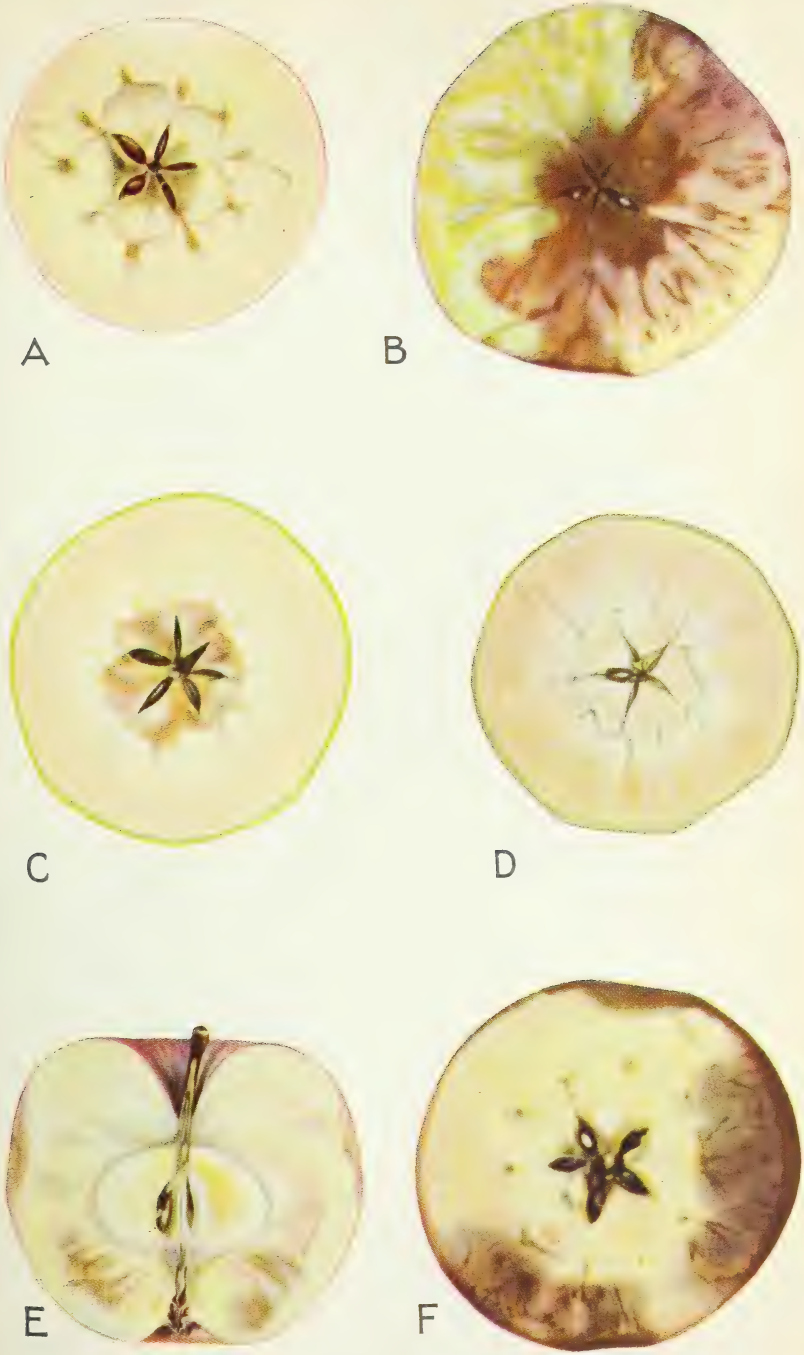
FREEZING INJURY

Freezing injury is a common source of loss in apples during the winter months. The greater portion of it occurs in transit, especially in fruit shipped from the Pacific Coast States, which must pass



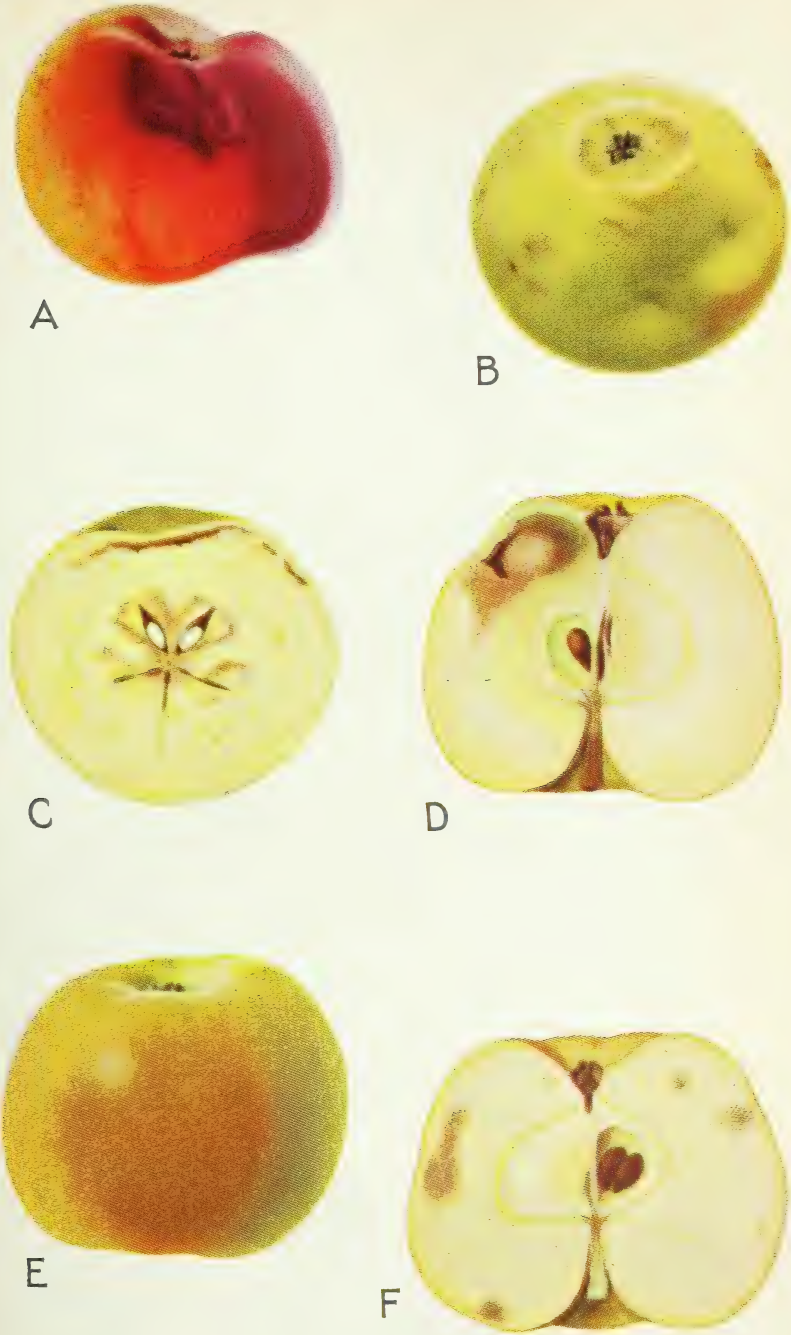
APPLE INJURIES

A, Drought spot on Winesap, outside view; B, lime-sulphur injury; C, hail injury on Jonathan; D, spray injury, probably by Bordeaux mixture, on Ben Davis; E, drought spot on Winesap, sectional view.



APPLE DISEASES

A, Water core on Winesap; B, water core on Rome Beauty, followed by internal breakdown; C, D, internal browning of Yellow Newtown; E, internal breakdown on Stayman Winesap; F, internal breakdown on York Imperial.



APPLE INJURIES

A, Heat injury on York Imperial; B, C, heat injury on Northwestern Greening; D, heat injury (hollow apple); E, sunburn on Yellow Newtown; F, cork.

through high altitudes and extremely low temperatures, often for several days. However, apples that show evidence of freezing injury upon reaching the market have not necessarily been frozen in transit. Freezing in the orchard sometimes occurs both in the East and in the West. There are also occasional opportunities for freezing injury during the handling or storing of fruit previous to its actual shipment.

At present there are no known symptoms of freezing injury that clearly indicate, for a single apple, the time when or the conditions under which the damage occurred. On both of these points the most reliable evidence is furnished by the distribution of the injury in the car, though even by that no more is indicated than that freezing occurred either prior to loading or during the transit period. Transit freezing occurs first at the doorway of the car, along the floor and side walls, and near the bunkers; upon prolonged exposure to low temperature it may extend deeper into the load. If freezing is not present in the outer parts of the load, no transit freezing should appear elsewhere in the car. If the injury is uniformly scattered through the package and through all parts of the load, in all probability the freezing took place before the product was loaded.

The amount of injury that an apple may suffer from freezing depends on the length of the exposure to low temperature, on how low the temperature goes, and on other conditions affecting the fruit when freezing occurs. Usually these conditions as well as the rate of thawing are unknown when the apples are inspected, and conclusions must be drawn from the appearance of the fruit at the time it is examined.

It should be remembered that a sound, healthy apple is a living organism. When it freezes, ice crystals form within the tissues (not in the cells but between them), and the tissues are injured or disorganized by the action of physical factors that interfere with the normal life processes of the fruit. Other kinds of disorganization, at first sight somewhat similar to freezing injury, are produced by exposure to high temperature, by treatment with ether and other poisonous substances, by diseases due to blue-mold or other organisms, and by the natural breakdown due to old age. The extent to which the life processes are affected depends largely upon the degree to which the disturbing factor is applied. If that factor is low temperature, the extent of the injury to the fruit will depend on factors already mentioned and may range from slight damage to complete disorganization in which every cell is browned and the apple is "frozen to death."

FREEZING POINT OF APPLES

Accurate determinations on several hundred specimens of the more important commercial varieties (Winesap, Stayman Winesap, Yellow Newtown, Ben Davis, Baldwin, Rome Beauty, Wagener, Jonathan, McIntosh, Tompkins King, Grimes Golden) show that the freezing point of these varieties ranges from 27.32° to 29.40° F.; the average is 28.43°. For any individual specimen, unless the temperature of the air surrounding it is suddenly lowered much below 27° to 29°, the temperature of the inside tissues often drops temporarily a degree or more below the true freezing point without any formation of ice.

This phenomenon—lowering the temperature of the tissue below its freezing point without inducing the formation of ice crystals—is known as "undercooling." If the temperature continues to fall, or if the exposure to the low temperature is prolonged, this resistance to freezing is overcome, the undercooling period is completed, ice quickly forms in the tissues, and the temperature rises rapidly to the approximate true freezing point regardless of the air temperature around the apple. After ice is formed in the tissues a further drop in the temperature of the surrounding air will be reflected in the temperature of the fruit. Somewhat under-ripe apples are more resistant to freezing than those fully ripe.

SYMPTOMS OF FREEZING

Many persons think that the presence of ice in an apple at the time of examination is prima facie evidence of freezing injury. Theoretically, they are right; practically, they may not be. The confusion is due to a failure to distinguish between slight freezing and "freezing to death", in which enough ice is formed to cause permanent and visible injury. Doubtless the least incipient ice formation injures the apple flesh to some degree, but so far as present knowledge goes there is no visible evidence of injury by such slight freezing nor any effect upon the market value of the fruit. If, however, the freezing process is carried somewhat further, a slight noticeable injury results, even though the cells may appear practically normal; if carried still further, the cells may be killed, in which event they turn brown. This condition is described subsequently. But, regardless of how much ice appears in the fruit, unless a significant proportion of the cells show this browning it is inaccurate to say that the apple shows freezing injury.

EXTERNAL APPEARANCE

If freezing has been slight, there may be no marked external symptoms of any sort; if it has been severe, the general outside appearance of the apple is strikingly affected. The surface is discolored in irregularly shaped areas—became so, in fact, very soon after the apple thawed out—and appears considerably darkened. It often assumes a water-soaked brown color closely resembling the color of apple scald, or it may become much darker, in some cases almost black. When apples are in a frozen condition the skin becomes slightly shriveled, but the shriveling usually occurs in the form of a network of wrinkles rather than as parallel lines of shrinkage such as are produced by normal evaporation. Careful measurements have shown also that the fruit actually becomes smaller, sometimes by as much as 10 percent of its original volume. On thawing, it practically regains its original volume, unless the freezing was very severe.

When apples thaw after having been badly frozen the skin becomes shriveled, particularly if the air in the storage place is very dry. This form of shriveling seems to be due to rapid evaporation after thawing of the water withdrawn from the cells and changed into ice in the spaces between the cells during the freezing process.

Shriveling, when slight, is accompanied by a reduction chiefly in size; when severe, by a marked reduction in both size and weight.

Apples that have been severely frozen frequently show noticeably sunken spots which may be a quarter of an inch deep or more, with a superficial diameter about equal to their depth. In virtually all cases these sunken spots develop at places that were bruised while the apple was still frozen. (See Bruises, p. 16.)

Apples that have been both bruised and frozen while in transit by rail frequently show flattened areas 1½ to 2 inches in diameter that are somewhat sunken and soft toward the center and have a dull-brown or slate color over most or all of the surface (pl. 10, A, B). The transit bruises described on page 16 are smaller in diameter, flat instead of sunken, the skin covering them is not slate colored, and the flesh beneath is firm.

It should be remembered, however, that during a short exposure to an air temperature several degrees below freezing considerable ice may form within the tissues and yet produce little or no effect that could be diagnosed as freezing injury.

INTERNAL APPEARANCE

Usually the best indications of freezing injury are found by examining a cross section of the fruit. If a cut is made crosswise through the middle of an apple that has not been frozen, there will be seen, about halfway between the center and the outside, 10 small dots, the natural color of which in most varieties is green or yellowish green, but in the Winesap, Esopus Spitzenburg, and some other varieties is occasionally tinged with red. These dots are the cut ends of the main fibrovascular bundles of the apple, which are connected with numerous but less conspicuous threadlike fibers extending throughout the flesh. The whole network, including the large bundles, constitutes the vascular (or food-and-water-conducting) system of the fruit, and, so long as the fruit remains on the tree, is in direct connection with a similar system in the twigs and branches.

When freezing occurs the cells of the vascular system are usually the first to be affected, especially if the freezing takes place rapidly; and they may be the only ones so affected. In cross section this injury is shown by a brown discoloration of the 10 large main bundles (pl. 10, C), the color being visible evidence that the cells have been frozen to death. Similar browning may occur in the smaller strands through the flesh and in the core tissue; it is frequently restricted to one side of the apple because of lower temperature on that side. In more extreme cases all of the tissues may be affected; the flesh then shows a solid color throughout which varies from bright golden brown to darker brown or almost black, depending on the variety of the apple and the severity and freshness of the freezing injury (pl. 10, D). These browned areas in whatever tissue found usually have a water-soaked appearance and in milder injury are translucent.

EFFECT OF FREEZING AND THAWING

It is generally believed that frozen apples are injured less by gradual than by rapid thawing. Careful investigation of the subject has shown, however, (1) that apples frozen rapidly when thawed

at 32° and 72° F. show an equal amount of injury, and (2) that in a packed box or barrel slowly frozen apples show more discoloration when thawed slowly (at 32°) than when thawed rapidly (at 50° or higher).

Apples that have been frozen are often dry and mealy, probably because of loss of water through evaporation from the injured tissues. The degree of mealiness increases with the amount of freezing but is not entirely absent even when freezing was only slight. The flesh sometimes appears flaky or corky and always lacks the normal crispness; in severely frozen specimens it collapses and becomes viscid, soft, and mushy.

If apples are frozen but not "frozen to death" they may thaw out with no apparent aftereffect except a slight softening of the flesh. This softening, however, means that their prospective storage life has been shortened. The amount of the reduction will depend on the variety, the degree of maturity of the fruit when frozen, and the severity of the freezing. There is no doubt that apples that have been solidly frozen throughout, even though for only a short time, will not hold up so well in storage, or for so long a time, as similar apples from the same orchard or the same storage lot or shipment that have not been frozen.

Apples should not be handled while they are frozen, because of the danger of serious damage from bruising. Bruises produced in this way frequently extend deep into the fruit, and the affected flesh is usually brown, soft, and somewhat watery.

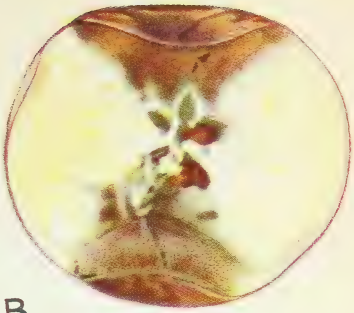
FREEZING INJURY AND INTERNAL BREAKDOWN

During January or even earlier, and continuing through the remainder of the storage season, it may sometimes be difficult to distinguish between freezing injury and the condition known as internal breakdown due to overripeness. The difficulty will be greatest when there is no evidence of freezing in transit. Internal breakdown may be followed by browning, but the color change, unlike that which often follows freezing injury, does not begin in the main fibrovascular bundles (in cross section, the 10 dots that surround the core). Instead, it may begin at any place in the flesh and usually does begin at many places. Seen in cross section, fruits affected with internal breakdown often show the following conditions: An outer shell of healthy flesh about a quarter of an inch thick surrounding a brown zone which extends inward in roughly triangular patches as far as the bundles or a little beyond; next to this is another zone of healthy flesh, and in the flesh at the core is a second area of brown.

In the Winesap overripeness is not usually followed by internal breakdown and browning. Specimens of this variety held at 32° to 35° F. for more than 21 months were at the end of that time still free from both of these conditions. They did show, however, a loose, wrinkled condition of the skin which suggested freezing injury but was probably caused by normal loss of water.

Internal breakdown is usually worse in large-sized apples and more marked at the blossom end than at the stem end. Freezing injury may affect apples of any size and is not necessarily or uniformly worse at one end of an apple than at the other. Yet when one side of an apple or even the whole apple shows in cross section

A

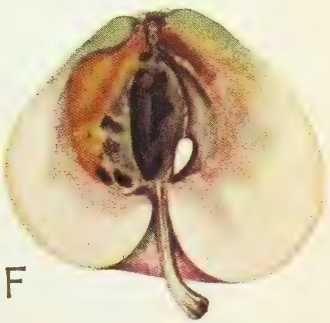


B

C

D

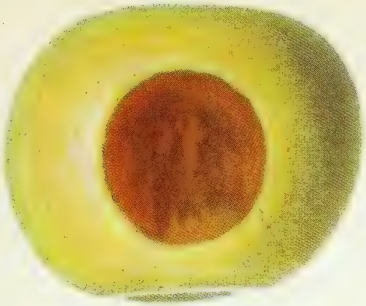
E



F

APPLE INJURIES

A, Freezing injury on Winesap; likely to be confused with transit bruising. Note the large flattened area, discolored over the whole surface and somewhat sunken. The apple came from the lowermost layer of a floor box in a refrigerator car and was frozen when found. B, Freezing injury; cross section of A. C, Section of a severely frozen Winesap apple showing discoloration of the primary fibrovascular bundles and the core tissue. D, Apple completely killed by freezing. E, F, Injury on Delicious caused by freezing when apple was young.

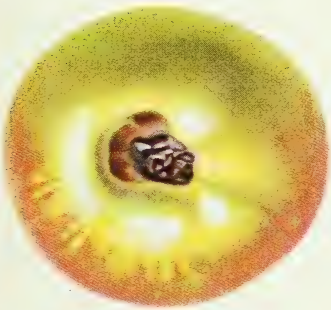


APPLE INJURIES

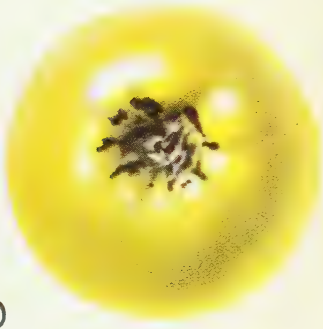
A, B, Transit bruising on Yellow Newtown. Apple taken in late March from bottom layer of a floor box in a refrigerator car; C, Rome Beauty apple showing (*a*) water-soaked condition of flesh characteristic of transit injury; (*b*, *c*) ordinary "box" bruises; D, transit bruising on Winesap; E, transit bruising on Delicious; F, Rome Beauty apple showing water-soaked flesh underlaid by a brown region. Both conditions are characteristic of transit injury on ripe apples. Note vascular browning.

A

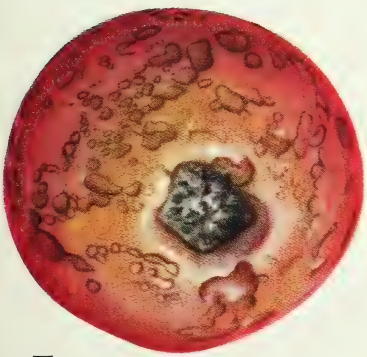
B



C



D



E

F

APPLE INJURIES

A, Acid injury followed by decay, on Rome Beauty; B, acid injury; C, arsenic injury followed by decay, on Winesap; D, arsenic injury on Yellow Newtown, no decay; E, alkali injury; F, ammonia injury on Winesap, produced by 12 hours exposure to an atmosphere containing 3½ percent ammonia gas.

a uniform brown color, it will be hard to determine whether the condition is freezing injury or internal breakdown. Reliance should then be placed, not on any one symptom or the examination of one apple, but on all the symptoms that can be found, in as many apples as can conveniently be examined.

Water-soaked bruises are not a sure sign of freezing injury, as will be seen by reference to Bruises, page 15. (*22*, *36*, *52*, *86*, *129*, *198*, *240*.)

FREEZING INJURY WHEN APPLES AND PEARS ARE YOUNG

When freezing temperatures occur at blossoming time or soon afterwards, the fruits that remain on the trees may nevertheless have suffered sufficient injury so that as they come to maturity they show various abnormal conditions. One of these conditions is the familiar "frost russet", which on apples may appear as narrow bands extending from the blossom end to the stem end of the fruit (pl. 6, D), or as a russeted ring lining the calyx cavity and occasionally extending outward from the cavity for a half inch or more. On pears it most commonly takes the form of bands encircling the fruit about half-way between the two ends. In addition, frost russet on both pears and apples sometimes has the diffuse irregular form characteristic of spray injury and rain russet.

A second condition, seen less frequently and then only on apples, is a persistence of the green color at the blossom end on mature fruits which over the rest of their surface have the color normal to the variety (pl. 10, E). The greening varies greatly in intensity and in the amount of surface covered. It may or may not be accompanied by russeting. Affected areas are occasionally so flattened and so dark green that they look like apple-cedar rust spots, but they do not, of course, show the pustules characteristic of rust. Badly damaged specimens are nearly always distorted at the blossom end, may have only a few poorly developed seeds or none at all, and usually show in cross or longitudinal section a blotchy or streaked browning in the flesh underlying the green areas (pl. 10, E, F).

FRUIT SPOT

(*Mycosphaerella pomi* (Pass.) Lindau)

Fruit spot ("Brooks' spot") in the United States is most common in the region east of Michigan and north of North Carolina and Tennessee, but it is occasionally serious in southwestern Missouri and northwestern Arkansas. It causes the greatest losses in New England, where 50 to 90 percent of the fruit may be affected in years when the disease is bad. In late years it has been one of the most important diseases in New Jersey. The disease also occurs in Canada and has recently been reported from Germany and South Africa. Varieties most seriously affected are Baldwin, Jonathan, Rome Beauty, Tolman Sweet, Grimes Golden, and Stayman Winesap, although many others have been reported as susceptible.

The spots are one eighth to one fourth of an inch in diameter and are deep red or black on red areas and dark green on green or yellow areas (pl. 3, A). The center of the spot is flecked with black, which

can be observed more readily by removing the surface of the spot with the thinnest possible paring. There will then be seen in the flesh underneath a number of very small brown or black specks, which are aggregates of cells killed by the fungus. These specks can sometimes be seen through the cuticle but are more likely then to be obscured by the surface discoloration. Owing to the collapse of the cells in the affected area, the larger fruit spots become slightly sunken. On overripe apples the spots are often surrounded by a band of brown.

Because of their speckled appearance, fruit spots caused by *Mycosphaerella* are easily distinguished from all other spot diseases of apples. They are further distinguished from bitter pit by not being markedly sunken except in later stages, by occurring only in the epidermis of the fruit, and by having no connection with the water-conducting system.

On fruit in cold storage the spots change but little. In delayed or cellar storage new spots may appear and older ones may seem to enlarge slightly. In the main this latter change results from the change in color of the fruit rather than from the actual enlargement of affected areas.

Infections on the fruit appear not earlier than June and may continued until August. Bordeaux mixture or lime-sulphur sprays are effective in controlling the disease. (*14*, *15*, *16*, *22*, *100*, *114*, *131*, *146*, *195*, *208*, *227*, *232a.*)

GRAY-MOLD ROT

(*Botrytis* spp.)

Gray-mold rot occurs on apples from the Pacific Northwest and from various producing sections in the eastern United States. It is not common on the market, however, and is seldom as destructive on apples as on pears.

As seen on apples from the Northwest, gray-mold rot is characterized by diseased areas that at first have a pale, translucent, watery appearance but soon change to a duller brown. In the early stages of the rot there are dark-brown spots around the lenticels about one eighth of an inch in diameter, which in their final form become reddish brown and have a pale or whitish center. These spots are most marked when the rot develops at low temperatures, and continue to give the fruit a "freckled" appearance even after it is completely rotted.

On northwestern fruit the disease has been found as early as November in common storage but usually not before February in cold storage. The Winesap variety seems to be affected more often than any other.

In gray-mold rot of eastern apples the affected tissues are characteristically light brown and rather soft, as in the northwestern form; no dark-brown or reddish-brown spots have been seen at the lenticels in diseased areas, however, and the name "spot rot" cannot properly be used, in the sense in which it is applied to the northwestern form. In the East the disease has been found on several of the more important commercial varieties.

Gray-mold rot of apples is caused by two, possibly three species of *Botrytis*, one of which is apparently the same as that found on pears. On apples, as on pears, the fungus is able to grow from diseased fruits to healthy ones lying near or touching them, and its growth is not entirely checked even by a temperature of 32° F.

The only control measures that can be suggested are careful handling of fruit and the frequent removal of all decaying fruit and other culls from the packing house and its immediate surroundings (p. 3). It is probable that the copper-treated wraps used for controlling gray-mold rot of pears (p. 53) would be of value for control of the rot on apples. The injury that may be caused by the use of such wraps is discussed on page 53. (*17*, *22*, *44*, *45*, *94*, *100*, *101*, *195*.)

HAIL INJURY

Early-season hail injury generally occurs at the blossom end or on one side of the apple, but only because of the position assumed by the fruit on the tree during this period. Later, when the fruit has become larger and heavier it generally turns downward, so that hail marks on well-developed fruit are more often made on the stem end.

Fruit injured early tends to outgrow the internal condition produced, but may become slightly misshapen as it develops. When fruit is struck by hail late in the season, the cuticle covering the affected spot may be cracked or torn but often remains intact. Such spots range from one fourth to one half inch in diameter, are slightly sunken, and the flesh beneath them is brown and somewhat spongy and dry because of loss of water from the bruised area (pl. 7, C). The spots are usually dry enough when the fruit is shipped so that they are not followed by decay, even though there are cracks in the skin and flesh.

Hail injury can be distinguished from other spots described in this publication by the fact that only the upper exposed part of the fruit is affected. This usually coincides with the blushed area, except on fruits injured by hail while still young and small.

HEAT INJURY

IN THE ORCHARD

Apples may be injured while still on the tree by excessively high temperatures following a period of relatively cool weather. The fact of injury is indicated by various symptoms, chief among which are (1) a dwarfing or distortion of the fruit (pl. 7, A, E; pl. 9, A, B); (2) the development of brown spongy or corky streaks in the flesh (pl. 9, C, D); (3) browning of the flesh around the core; (4) browning and collapse of the tissue beneath the skin, making an almost complete layer of dead tissue surrounding the sound interior portion of the apple.

It is believed probable that heat injury and drought injury are closely related and gradually shade into each other. This hypothesis, however, does not eliminate heat as the significant factor initiating the four injuries listed above.

IN THE WASHING TANK

When apples are submerged in washing solutions heated to 100° F. or higher for periods of 3 minutes or longer, there is considerable danger of injury to the fruit. The results of this injury usually appear within 10 days or 2 weeks in the form of latitudinal cracks around the calyx, which often continue out on to the cheek of the apple. Only when considerable arsenic is dissolved in the washing solution does the cracked skin become blackened. Characteristically it is grayish or yellowish in color, resembling hydrochloric acid injury, for which it might be mistaken. It can be produced, however, by the use of heated water alone.

Apples are somewhat more susceptible to this type of injury at the time of harvest than after being kept for several weeks. Fortunately, it is generally not necessary to use heated solutions at harvest time, unless unusual spray practices have been followed. Likewise, few washing methods or devices require exposure of the fruit for a period long enough to cause injury, even when heated solutions are used. Injury by heated washing solutions is a factor that must be considered chiefly in connection with dipping tanks or other home-made devices used in small-scale operations. (*26*, *70*.)

HONEYDEW

Honeydew on apples is caused by aphids and certain other sucking insects. This sticky substance furnishes a favorable medium for the growth of sooty molds, which sometimes cover much of the surface of the fruit. Although these molds are superficial, and usually do not affect the fruit directly, they detract from its appearance.

INTERNAL BREAKDOWN

Internal breakdown occurs in apples from all of the various fruit-growing sections of the United States. It has been observed most often in Jonathan, Stayman Winesap, Rome Beauty, Wagener, and certain summer varieties that quickly become overripe; but Delicious, Esopus Spitzenburg, Yellow Newtown, Baldwin, Winter Banana, and Rhode Island Greening are also frequently affected.

Internal breakdown often characterizes the end of the storage life of apples when they are not affected by fungous rots. It may, however, occur earlier as a result of growing, handling, or storage practices, and may follow water core, freezing, or bad bruising. It is characterized by a breaking down and browning of the interior of the apple, sometimes only on one side or surrounding a bruise, sometimes throughout the flesh, and quite often in a central area surrounded by a ring of normal tissue (pl. 8, E, F). The latter condition is especially common in Jonathan and Delicious. The riper side of the apple is more often affected than the greener side, and the blossom half more than the stem half. The skin of affected fruits may be normal in appearance, yet it is often slightly duller and darker than normal and in later stages of the disease sometimes becomes cracked.

Apple flesh affected by internal breakdown is usually mealy rather than wet and soggy. (See Soggy Breakdown, p. 45.)

Internal breakdown is at times mistaken for freezing injury. In distinguishing between the two it is of assistance to bear in mind that a large part of the browning in frozen apples occurs at bruises extending inward from the surface (see Bruises, p. 16), and that freezing injury may occur at any point on the apple without relation to maturity or morphology. On the other hand, the browning from internal breakdown at a bruise rarely assumes a radial direction, is usually accompanied by a greater degree of mealiness, and includes more of the surrounding tissue.

Internal breakdown occurs most often on large-size overmature apples and on those that have been forced late in the season. It is sometimes the result of holding the fruit on the trees too long, waiting for color, and can often be traced to delay in cooling the fruit after it has been harvested or to the fact that the fruit has been held in storage at too high a temperature or beyond its proper season. Internal breakdown also often follows water core, as previously noted, and for this reason it is usually considered hazardous to store water-cored apples. The amount and seriousness of internal breakdown varies from year to year, apparently being dependent to a large extent upon growing conditions.

The little that can be done to control internal breakdown after picking is best done by handling promptly into cold storage at 31° to 32° F. Breakdown is particularly serious in common storage, but fruit with a decided tendency toward it cannot be relied on for late keeping even in cold storage. (*22*, *48*, *62*, *80*, *100*, *162*, *172*, *173*, *174*, *179*, *180*, *186*, *195*.)

INTERNAL BROWNING

Internal browning is a nonparasitic storage disease that is decidedly regional in its occurrence. It is particularly serious in Yellow Newtown apples grown in the Pajaro Valley in California, and also occurs in Yellow Bellflower and other varieties from that section, which has cool, cloudy, or foggy weather through the growing season. It is occasionally found in Yellow Newtown from other States, notably Washington, Oregon, Virginia, and New York, and in Rhode Island Greening from New York.

Internal browning differs from internal breakdown in the fact that the affected tissues are not soft and also in the further fact that the browning first appears as somewhat elongated areas usually radiating out from the central portion of the apple and from the primary vascular bundles (pl. 8, C, D). The outer fleshy portion of the apple may also show radiating lines of brown tissue, but this condition is usually accompanied or preceded by the more prominent development around the core, shown in plate 8, B. Internal browning does not manifest itself by any abnormal appearance of the skin of the apple, and the disease can be detected only by cutting into the fruit.

Internal browning apparently has a close relationship to soft scald and soggy breakdown in the conditions responsible for its occurrence. The usual cold-storage temperatures (31° to 32° F.) are particularly favorable to its development, and control can best be secured by storing the apples at a temperature of 36° to 40°. However, the tendency to develop internal browning is inherent in the fruit when it comes from the tree. Low temperatures during the growing

months have been found to favor the disease. Fruit from the interior shaded portions of the tree is more susceptible than that from the exposed portions, and fruit from trees bearing a light crop is more susceptible than fruit from trees bearing a heavy crop. (*8*, *22*, *100*, *125*, *126*, *127*, *171*, *239*.)

JONATHAN SPOT

Jonathan spot occurs on apples grown in all parts of the United States and is also known to occur in other parts of the world. The variety most commonly affected and on which the disease was first described is Jonathan; other varieties showing spots so similar they are generally classed as Jonathan spot are Esopus Spitzenburg, Wealthy, Yellow Newtown, Grimes Golden, Gravenstein, Ortley, Arkansas Black, Twenty Ounce, and Wolf River.

The spotting is apparently not caused by either fungi or bacteria. It is common after a dry season and in some years is more common on large apples than on small ones. It is occasionally found on ripe apples before picking, but is most prevalent on apples in transit or storage, especially if temperature and humidity are high and ventilation is poor.

Jonathan spots appear in the early stages as brown, roughly circular areas one sixteenth to one eighth of an inch in diameter which are abruptly but only very slightly sunken; in later stages they become somewhat more sunken and show as irregular lobed areas sometimes a quarter of an inch across (pl. 5, A). In early stages the spots are confined to the color-bearing cells of the skin, but underlying tissues become affected as they dry out after the skin is killed. These spots sometimes become infected with *Alternaria* or other rot fungi, and when this happens they will be found to overlie a brown spot that extends into the flesh for an eighth of an inch or more. Naturally, the depth of such spots depends on how long the fruit is exposed to conditions that favor decay.

The disease is of importance chiefly because of its effect on the appearance of the fruit, although it is sometimes followed by decay, as mentioned above. Its most serious characteristic is a tendency to develop in transit or storage to such an extent that marked damage results to fruit that was apparently in good condition when shipped or stored.

Brown spots that resemble Jonathan spot are sometimes seen on Rome Beauty apples. These, however, seem to occur only at lenticels; they have a blurred indefinite edge, and are rarely sunken, even as slightly as typical spots on the Jonathan variety. Nothing is known of their relation to orchard or storage conditions except that they do not usually develop until late in the storage season. In the absence of evidence to the contrary, it seems best to consider them a form of Jonathan spot.

The most effective method of controlling Jonathan spot is to move the apples promptly into cold storage, avoiding delays at warm temperatures. (*18*, *22*, *25*, *62*, *80*, *100*, *114*, *168*, *176*, *179*, *180*, *185*, *217*.)

KING DAVID SPOT

King David spot occurs on apples of the King David variety. The spots appear as black or dark-greenish areas up to about one fourth

of an inch in diameter and are generally confined to the skin, although they occasionally extend into the flesh a very short distance. No spots occur deep in the flesh.

King David spot is typically an orchard disease and does not develop in storage. Green areas on the fruit are more often affected than red ones; sometimes the spots are confined to the calyx cup or the stem basin.

Nothing is known of how the spot is caused or how it can be controlled.

LEAF-HOPPER SPECKING

After infestations by several species of leaf hoppers, apples often show numerous superficial brown or black specks about the size of a pinhead or slightly smaller. These are usually most numerous on fruit that was exposed to dust at the time when the leaf hoppers were most active. The washing of fruit to remove spray residue incidentally removes the leaf-hopper specks.

LEAF-ROLLER AND GREEN FRUIT-WORM INJURY

Large russeted and corky scars, often in scooped-out areas, sometimes in the form of small slightly raised or undulating spots, together with more or less distortion, are often found on marketed apples. Such injuries usually are the result of feeding by certain chewing insects early in the season when the apples are small. The exact identity of the insect concerned cannot be determined after the injury has grown over. Among the insects causing this type of injury are the fruit-tree leaf roller (*Cacoecia argyrospila* Walker) (pl. 22), the green fruit worms (*Graptolitha antennata* Walker and other species), and the rusty tussock moth (*Notolophus antiqua* L.).

The larvae of the red-banded leaf roller (*Eulia velutinana* Walker) consume extensive areas of skin and outer flesh of the apple, usually in the calyx or stem end, where two apples touch, or where a leaf is in contact with the apple (pl. 20, D). This species is usually most abundant late in the season. As a result, the injured areas do not heal over, but offer a favorable opportunity for the entrance of various rot organisms. (*184*, *201*.)

MISCELLANEOUS ROTS

In addition to the rots discussed under various special headings, there are others of minor importance, from which the following fungi have been isolated: *Mucor piriformis* Fischer, *Endomyces mali* Lewis, *Pleospora fructicola* (Newton) Ruehle, *Mycosphaerella tulasnei* Jancz., *Gliocladium viride*, Matr., *Phoma* spp., *Coniothyrium* spp., *Microdiplodia* sp., *Pestalozzia hartigii* Tub., *Coryneum foliicolum* Fckl., *Oospora* sp., *Cephalosporium carpogenum* Ruehle, *Penicillium* spp. (other than *P. expansum*), *Aspergillus* spp., *Trichoderma* sp., *Trichothecium roseum* (Pers.) Lk., *Sporotrichum carpogenum* Ruehle, Hormodendron *cladosporioides* (Fr.) Sacc., *Stemphylium congestum* Newton, *S. congestum minor* Ruehle, *Fusarium* spp., and *Epicoccum granulatum* (Lév.) Bres.

Most of these fungi grow slowly at cold-storage temperatures, and only a few are as active at ordinary temperatures as gray mold or the species of blue mold (*Penicillium expansum*) that is most com-

mon on apples and pears. The rots they cause are usually firm and vary in color from light to dark brown, but are not readily distinguishable from one another except by laboratory study. No attempt will be made to describe them here. (*58*, *76*, *85*, *100*, *116*, *131*, *132*, *167*, *169*, *199*, *200*.)

PANSY-SPOT INJURY

Pansy spots are white or greenish areas a half inch or more across, which are frequently lobed in such a way that the outline suggests the shape of a pansy flower (pl. 19, G). They are caused by the flower thrips (*Frankliniella tritici* Fitch) and probably by other species of thrips. At the centers may be found greenish-brown corky spots, seldom more than an eighth of an inch in diameter, which develop around the punctures made by the female thrips in the process of egg laying. The spots show conspicuously on green immature apples and often become prominent and serious defects at harvest, on the McIntosh variety in particular, when the red color (in the spots) seems to be permanently lost. On some other varieties the spots may become quite inconspicuous as the natural coloring of the fruit develops. Evidence has been obtained that the spots do not enlarge or change in any other way while the fruit is in storage.

Partial control may be obtained by spraying the trees when in full bloom with nicotine sulphate (40 percent nicotine) in the proportion of 1 pint in 100 gallons of water, with the addition of enough soap to make the solution soapy to the touch. A casein spreader may be used in place of soap. The addition of nicotine to the calyx spray is also helpful in controlling the thrips. (*40*, *163*.)

PEAR-LEAF BLISTER-MITE INJURY

(See Pears, Pear-Leaf Blister-Mite Injury, p. 53)

PHYTOPHTHORA ROT

(*Phytophthora* sp., probably *P. cactorum* (Leb. and Cohn) Schröt)

Phytophthora rot is a parasitic disease of apples and pears and has been found in fruit from New York, Connecticut, Michigan, Indiana, Washington, and Idaho. So far as known it does not cause heavy damage in any of these States and it is not common on the market. The varieties of apples found affected on the market are Twenty Ounce, Tolman Sweet, Baldwin, Winesap, Jersey Sweet, Wealthy, Gideon, Rhode Island Greening, Tompkins King; of pears, Clairgeau, Kieffer, Bosc, Howell, Bartlett, Anjou, Angouleme. Doubtless other varieties of both kinds of fruit are sometimes attacked. The rot is able to develop slowly at cold-storage temperatures, but there is no evidence that it can spread from affected to sound fruit, either in transit or in storage.

Phytophthora rot on apples as seen from the outside is light brown in color (pl. 4, A); on pears it is dark brown to black. In both apples and pears there is always a marked browning of the bundles or strands that conduct food and water through the fruit. This browning occurs in the large bundles near the core and the smaller ones throughout the flesh, and from the former may even extend

into the stem (pl. 4, B). In apples the flesh surrounding the bundles is slightly browned; in pears scarcely at all. In some varieties of pears, notably Clairgeau, the flesh is in fact decolorized and has a clear, water-soaked appearance very much like that of apple flesh affected by water core. The flesh of both apples and pears sometimes becomes slightly spongy but is usually as firm as sound, healthy flesh; it rarely becomes soft and mushy, like that found in decay produced by *Rhizopus* or blue mold. In cross section the area affected by *Phytophthora* in both kinds of fruit has an indefinite boundary so that it is impossible to make a clear separation of diseased from healthy flesh, as can so easily be done in fruits attacked by *Rhizopus* or blue mold. The affected flesh has no marked odor or taste.

In the orchard this rot occurs either on windfalls or on fruit hanging low on the tree, hence it seems likely that the fungus *Phytophthora* causing it lives in the soil. Confirmation of this theory is found in the fact that pears or apples laid on moist soil from orchards where the rot occurs and held at a temperature of 70° to 80° F. will develop Phytophthora rot in 2 to 3 weeks. The fungus is apparently able to penetrate the uninjured skin of the fruit, since on many of the infected specimens observed it was impossible to discover skin breaks of any sort. On the market Phytophthora rot has been found in boxed apples and in basket shipments of low-grade pears.

To prevent the appearance of Phytophthora rot in marketed fruit it is apparently only necessary to avoid putting windfalls into the pack. (*42*, *75*, *114*, *196*, *235*.)

PINK-MOLD ROT

(*Cephalothecium roseum* (Fr.) Cda.)

Pink-mold rot is chiefly an apple disease, though it is sometimes found on summer or fall varieties of pears. It was formerly more prevalent and destructive than at present, because of the custom, now virtually discontinued, of piling apples and allowing them to "sweat" before packing. It is usually found following scab and is still rather common in storage and transit on Baldwin, Rhode Island Greening, and other varieties susceptible to scab. It may also occur on apples while they are still on the tree. On certain russet varieties the rot sometimes follows an injury resembling Jonathan spot, and it may occur independent of scab or any other injury. In the latter case the fungus apparently enters at the lenticels. The disease is more common in New York, Ohio, Maryland, Virginia, and West Virginia than in any other parts of the country. It has also been reported from Nebraska.

In its most common form, that is, following scab, the disease is found in two rather well-marked stages, with various transition stages between them. In the first of these the rot appears as definitely sunken brown bands about an eighth of an inch wide encircling scab spots. At such places there is sometimes a growth of white fungus threads, or under warm moist conditions a pink mass made up of these threads and the pink spores they produce. If conditions are favorable, the second or final stage of the rot soon follows.

This is characterized by chocolate-brown, sunken areas of irregular outline varying in diameter from half an inch to 2 inches or more. Scattered over the surface of these areas are depressed circular spots the color of which is a lighter brown than the rotten area surrounding them (pl. 1, F). Under market conditions this late stage of the rot is less likely to show the white fungus threads and pink spore masses than is the first stage. At any stage the rotted areas are rather firm and dry, or at least not watery, and the affected tissues have a bitter taste.

Pink-mold rot is sometimes confused with fisheye rot, caused by *Corticium centrifugum*. The two can generally be distinguished by the fact that on fruit affected with pink-mold rot there is usually a conspicuous white to pinkish growth of the fungus at the center of the affected spot, whereas spots of fisheye rot show very little fungus growth except under conditions of high humidity. Pink mold is a shallow-growing fungus, penetrating the flesh about an eighth of an inch, whereas *Corticium* grows much deeper and in its late stage extends to the core.

Below 50° F. pink-mold rot develops very slowly and is not at all likely to start at new places; at 32° it is checked almost entirely. Control is therefore best obtained by means of refrigeration. The rot rarely spreads from one fruit to another unless scab is present and the fruit is held for some time at fairly high temperatures. (*22*, *47*, *57*, *58*, *100*, *114*, *195*.)

POWDERY MILDEW

(*Podosphaera leucotricha* (Ell. and Ev.) Salmon)

Powdery mildew is a fungus that attacks the foliage, twigs, blossoms, and fruit of the apple and the pear. On all of these it shows first as small grayish or white feltlike patches of fungus growth, which by enlargement may in time entirely cover the part affected. Symptoms that develop later are (1) curling and wrinkling of the leaves, (2) blighting of the blossoms, (3) stunting or killing of the twigs, and (4) stunting and russeting of the fruit. The fungus may become established on the fruit either by spore germination on the fruit surface or by growth down the stem from infected twigs.

Mildew russeting on the apple fruit, in its commonest form, has a peculiar lacy or netlike appearance which distinguishes it rather definitely from russeting caused by spring frosts or spray mixtures (pl. 3, F). In the more unusual form of solid patches in which it sometimes occurs it might be mistaken for one or the other of the two injuries just named, except that there is always more or less of the lacy russeting around the edges of the larger affected areas. Furthermore, the surface of the affected areas is not roughened as in spray injury but is smooth.

On the pear, mildew more commonly attacks the fruit than the foliage or twigs, producing blackened areas which become hard and may eventually crack open. On pears it is most serious when they are interplanted with susceptible varieties of apples.

Powdery mildew is known to occur in nearly all parts of the United States where apples are grown, but is more serious in the

Northwest and on the Pacific coast generally than elsewhere. It has been reported as seriously affecting pears of the Flemish, Bartlett, Louise, Anjou, and Idaho varieties in Washington and Oregon and is known to occur sometimes on quince, cherry, and plum in various parts of the country. On the market it is found chiefly on apples from Washington, Oregon, and California, the varieties most often affected being Jonathan, Grimes Golden, Winesap, Gravenstein, Yellow Newtown, Ben Davis, Gano, and Esopus Spitzenburg.

Control of the disease depends mainly on proper spraying with commercial lime-sulphur or other sulphur sprays. (*9*, *63*, *64*, *100*, *114*, *120*.)

PLUM-CURCULIO INJURY

(*Conotrachelus nenuphar* Hbst.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Injury caused by the plum curculio is often found on apples in the eastern half of the United States. A very common type of mark is a fan-shaped scabby or corky area, varying in size from an eighth to a half inch across. When the adult curculio punctures the apple and lays its egg, the puncture is then partially surrounded by a small crescent-shaped slit. As the fruit grows, this forms a corky, russeted scar. The punctures made for the purpose of feeding are smaller and do not develop into fan-shaped areas. When abundant, this scarring causes the apples to be badly deformed and misshapen (pl. 21). In the fall adult curculios of the new generation often feed on the ripening fruit, causing shallow pits, mostly around the calyx and stem ends (pl. 20, E). These do not have opportunity to heal over, and may permit the entrance of decay organisms.

CAUSE

The adult plum curculios are hard-shelled beetles with long snouts. They hibernate in the adult stage in trash in the orchards, or in brush or waste land nearby, and begin to return to the apple trees about as they come into bloom. Most of the egg laying and feeding is done during a period of 4 to 6 weeks after petal fall, although a limited amount of feeding is done in the fall. Many of the larvae in the fruit are killed by the pressure of the rapidly growing tissue, but enough of them survive in fallen fruit to maintain the infestation.

CONTROL MEASURES

The curculio may be rather readily controlled by thorough spraying with lead arsenate during the month following petal fall.[5] Some State experiment stations recommend, in addition to the regular codling-moth applications at petal fall and a month or so later, two special curculio applications, one 7 days and another 17 days after petal fall. In lighter infestations a single special application 10 days after petal fall appears to be sufficient.

[5] As to the use of lead arsenate, particularly with regard to spray residue, see the first paragraph on Control Measures, under Codling-Moth Injury, p. 22.

Thorough cultivation of the orchard during midsummer is of value in destroying the delicate pupae in the soil. The cleaning up and destruction of trash in the orchard and nearby areas are of value, because they render conditions unfavorable for hibernation. (*184*, *201*.)

RED SPOTS

Aphids, particularly the green-apple aphid, sometimes cause red spots or specks on yellow or green varieties. These may be confused with the red spots caused by San Jose scale but differ from them in having no light-colored center.

A red skin spot is particularly common on Yellow Newtown and other green or yellow apples, on the side that has been exposed to the sun. It consists of a narrow reddish halo or band surrounding some mechanical injury or even the lenticels if these have been torn by the growth of the fruit after they had corked over. Exposure to intense sunlight or the penetration of the skin by spray materials also seems to stimulate a localized formation of red color on green varieties or on the green portions of red varieties. Such spots are sometimes mistaken for the effects of San Jose scale, but they can usually be distinguished by their being located at a lenticel and by the fact that they have no white or light-colored center.

RHIZOPUS ROT

(*Rhizopus* sp., probably *R. nigricans* Ehrenb. ex Fr.)

Rhizopus rot is seen occasionally on apples and pears on the market, but always on stock that has been weakened in some way, as, for example, by overmaturity or by freezing injury. Affected tissues are soft and watery and have a sour smell.

Rhizopus is a fungus that occurs widely in nature. It is distributed both by contact and by means of its spores and is much more destructive on berries, grapes, and peaches than on apples and pears. It can be distinguished from the other two fungi that most often attack fruits, blue mold (*Penicillium*) and gray mold (*Botrytis*), by its dark-colored coarse mycelium and the minute white to nearly black fruiting bodies in which the spores are borne.

Rhizopus rot is not likely to occur on pome fruits if they have been handled carefully throughout the process of picking, packing, and transporting to market. If it becomes established in these fruits, it can be controlled by keeping the fruit temperature below 50° F.

SAN JOSE SCALE INJURY

(*Aspidiotus perniciosus* Comst.)

The evidence of injury by the San Jose scale most commonly noticed on market apples is the presence of small reddish areas about one eighth of an inch in diameter (pl. 19, A). At the center of each of these reddish areas is usually a light-colored spot, marking the place formerly occupied by the tiny scale insect before it was rubbed off in the handling of the fruit at harvest or later. In depressed areas, such as the calyx or stem ends, the scales may still be present. The scale covering is gray to grayish brown, less than a sixteenth of an

inch in diameter, with a raised nipple at the center, surrounded by a depressed ring. Occasionally a very small black scale, the stage that lives through the winter, is found. Underneath the covering is the scale insect itself, lemon yellow in color; the females are roughly circular in outline, whereas the males are elongate.

Spots suggesting the presence of scale insects may be caused by several other factors. Certain rot infections in the early stages resemble scale spots, even to the red ring, but the brown or black center cannot be rubbed off. A red spot similarly suggesting a scale insect is sometimes caused by green aphids feeding on the fruit. In this case, however, there is no light-colored center.

The San Jose scale may be controlled by spraying at any time after the leaves have dropped in the fall, or before the buds open in the spring, with winter-strength lime-sulphur, with oil emulsions, or with miscible oils. The oil sprays are more completely effective and are preferable. For detailed information regarding control measures as well as on the life history, see the following references (*73*, *74*, *83*, *165*, *183*, *184*, *194*, *201*).

SCAB

(*Venturia inaequalis* (Cke.). Aderh.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Scab is an orchard disease that attacks the leaves, twigs, and fruits of the apple. It occurs in all apple-growing sections of the United States but is most destructive in the cooler regions of the Eastern States, the upper Mississippi Valley, the coastal sections of the northern Pacific Coast States, the apple-growing sections of Idaho and Montana, and in the mountainous portions of Virginia, Arkansas, and other Southern States. In the northern United States it is the most destructive of all apple diseases. Farther south the losses caused by scab are often exceeded by those caused by blotch and bitter rot. The Plant Disease Survey of the United States Department of Agriculture estimates the average annual loss from scab in the United States during the 5-year period ended December 31, 1930, as 6.5 percent, or 9,332,000 bushels. There is great variation from year to year and from one section to another in the susceptibility of apple varieties to scab. The commercial varieties usually most susceptible are McIntosh, Fameuse, Wealthy, Baldwin, Ben Davis, Rome Beauty, Rhode Island Greening, and Oldenburg.

Scab spots on the leaves appear first on the lower side as olive-colored areas which have a tendency to spread out irregularly along the veins or the midrib. In the beginning they are slightly darker than the healthy leaf surface; later they turn brown or almost black and take on a velvety appearance. On the upper side the lesions have at first a lighter green color than the healthy surface of the leaf, but later they present the same velvety appearance described for the lower side. Occasionally there is considerable distortion of the surface; toward the end of the season many of the diseased spots die, shrink, and become cracked and ragged. In most sections the disease is rare on the twigs. The bark becomes blistered and later ruptured in places, so that affected twigs have a scurfy appearance very much like that shown by scabby pear twigs.

On the fruit the disease appears as irregularly circular spots one eighth to one half inch in diameter which have either a dark-green to nearly black surface, or in later stages a brown, russeted, rough surface with merely a fringe of dark green or black around the margin (pl. 3, D). The difference between the two is due partly to difference in age (the velvety areas being the younger) or to a rubbing off of the dark-colored material (fungus threads and spores) during the processes of picking and packing. Spots typically dark green and velvety generally show a ragged, papery fringe of the outermost part of the skin, which has been loosened from the tissues beneath by the growth of the fungus. The spots are usually most numerous around the blossom end, and when infection is severe they may coalesce to form large irregular lesions an inch or more across. Badly diseased fruits are often misshapen because of dwarfing on the side where the infection occurs.

CAUSAL FACTORS

Apple scab is caused by the fungus *Venturia inaequalis*. This fungus winters over on twigs and fallen leaves, producing during rainy weather in the spring immense numbers of spores, by which the disease is spread to all susceptible parts of the tree. Although most of the infection takes place in the spring, there is some throughout the growing season, because of the spores produced on leaves and fruit that were infected in the spring. The spores produced on the dead leaves in early spring are borne in minute sacs or asci (whence their name ascospores), in special flask-shaped bodies called perithecia; the spores produced during the growing season are known as conidia and are borne free on the ends of short branches of the mycelium. Each kind can give rise to the other, and each produces mycelium which is the cause of the one disease, apple scab.

The severest infection by the scab fungus occurs in early spring, about blossoming time. It is caused mainly by ascospores discharged from dead leaves of the preceding year. The condition most favorable for ascospore (primary) or conidial (secondary) infection is a gentle continued rain followed by a period of cool cloudy weather. A heavy rain followed by clearing is much less favorable, the important factor being the length of time the tree remains wet so as to favor spore germination.

The disease does not develop to any marked extent in transit, but it may develop in storage (storage scab), especially if late infection has occurred in the orchard. On apples from the Northern and Northeastern States it is often followed by pink-mold rot, which develops both in storage and in transit.

The development of scab on fruit in cold storage is usually small. Some lesions enlarge slightly during several months of storage, but rarely increase their diameter by more than one eighth of an inch. It is usually impossible to distinguish the lesions that have enlarged in storage, since their characteristics are only slightly different from those of lesions produced in the orchard. The greatest development of scab on stored fruit results from late infections. Some varieties of apples are susceptible until picked and may become infected if there are unusually long rainy periods late in the season. The resulting spots may appear soon after storage, or, if inoculation in the

orchard is very late, they may appear after several months of storage. Such spots vary in diameter from one sixteenth to one quarter of an inch. They are circular, darker in color than the field lesions, and have definite smooth borders (pl. 3, B).

Often the cuticle above the spot is not broken and the surface is shiny, dark brown to jet black, although it is usually roughened by the pressure of the mycelium beneath. Such spots, on account of their color, are sometimes confused with blotch. They can be distinguished from it, however, by the fact that no fruiting bodies are developed and by the further fact that the edges of the spots never show the marked feathery fringed appearance characteristic of the early stages of blotch. On overripe fruit the lesions may enlarge rapidly. The high humidity and temperature found in common storage also favor development of the disease.

CONTROL MEASURES

Spray schedules for scab vary considerably in different parts of the country. Under ordinary conditions in most regions the disease can be controlled by applications of lime-sulphur (either the commercial liquid or the commercial powdered form) for the prepink and the pink sprays, and again just after the petals fall, followed in about 10 days and again late in July or early in August by applications of lime-sulphur or sulphur dusts. In some sections Bordeaux mixture is substituted for lime-sulphur in the summer applications to avoid injury to the fruit from sulphur sprays applied in hot weather.

It is also advisable to rake and burn the dead leaves or to plow them under some time before the growing season begins, though such a procedure should never be considered as more than merely supplementary to spraying. (*2*, *10*, *22*, *31*, *47*, *53*, *54*, *55*, *62*, *71*, *75*, *100*, *105*, *114*, *120*, *123*, *124*, *130*, *147*, *175*, *183*, *192*, *195*, *202*, *208*, *209*, *210*, *220*, *224*, *232*, *237*.)

SCALD

OCCURRENCE, SYMPTOMS, AND EFFECTS

Scald is one of the most serious storage and transportation diseases of the apple and occurs on fruit from all producing sections of the country. No variety is entirely immune, but there is a wide variation in susceptibility. Among the varieties most seriously affected are York Imperial, Grimes Golden, Arkansas (Mammoth Black Twig), Rome Beauty, Rhode Island Greening, Baldwin, Wagener, Stayman Winesap, Yellow Newtown, and Winesap.

Scald is a disease that affects chiefly the skin of the apple and is confined largely to the greener side (pl. 5, B). Bright-red fruit areas are rarely affected. In mild cases the disease appears as a mere superficial browning of the skin, but in more severe cases the entire skin layer is killed and sometimes broken down to the extent that it will slough off readily from the underlying tissue. In some instances the flesh of the apple becomes dead and brown to a depth of a fourth of an inch or more and has much the appearance of a rot; but true rots usually spread down into the flesh in more or less conical shape, while scald is diffuse.

Apples usually show but little scald while held continuously in cold storage, but fruit that is apparently free from the disease at 32° F. often becomes badly scalded after a few days' exposure to warm air. However, the higher temperature does not really cause the scald; it merely brings out what was already latent in the fruit.

Scald is worse on immature than on mature fruit, and worse on apples from heavily irrigated trees than on those from trees receiving more moderate irrigation. It develops more rapidly at high than at low temperatures and is worse in standard commercial barrels than in more open packages, such as the box, basket, or ventilated barrel. Open stacks and air spaces that provide air circulation in the storage room contribute to the prevention of scald, but cannot be relied upon for the control of the disease.

Delayed storage may greatly increase the later development of scald, especially if the fruit receives little ventilation during the delay, although with immature fruit a delay with free exposure to the open air sometimes reduces the later development of scald.

CAUSAL FACTORS

The real cause of scald is the accumulation within the apple tissues of certain gases that are produced by the apples themselves as a result of their continued respiratory activity. These gases can be removed by aeration and ventilation, but this is difficult to accomplish in closed packages under the usual storage conditions. However, the injurious gases can be absorbed by oils, which give the basis for a most efficient and practical method of scald control, that of packing the apples in oiled (not waxed) paper.

CONTROL MEASURES

Oiled wraps should be used on boxed apples and shredded oiled paper should be scattered among apples in barrels, hampers, and baskets. About one half pound of shredded paper is required for each bushel of apples, and it must be well distributed in the package, practically every apple having more or less contact with the paper. The oiled wraps should carry at least one fourth of a gram of oil per sheet, and both wraps and shredded oiled paper about 15 percent of their finished weight in odorless, tasteless mineral oil, although 18 or more percent of oil is desirable, especially if lightweight paper is to be used on the more susceptible varieties of apples. The apples should be packed in the oiled paper as soon as possible after picking. Unless this is done within 3 or 4 weeks it is not usually possible to overcome the tendency to scald. (*11*, *13*, *19*, *20*, *21*, *22*, *23*, *24*, *28*, *60*, *62*, *80 86*, *100*, *140*, *143*, *144*, *179*, *180*, *182*, *186*, *195*, *236*.)

SOFT SCALD

Soft scald is a nonparasitic disease of apples that is sporadic in its occurrence even on susceptible varieties, yet sometimes causes heavy losses. It occurs most frequently on Jonathan and Rome Beauty but is occasionally found on Stayman Winesap, Winesap, Winter Banana, Baldwin, Wagener, Grimes Golden, Northern Spy, and other varieties.

The disease is characterized by peculiar patches and ribbonlike areas of brown tissue on the surface of the apple and by the sharp line of demarcation between the diseased and healthy tissue (pl. 5, F). Sometimes only the skin of the apple is affected, but more often the browning extends into the flesh for an eighth of an inch or more. Black spots on areas injured by soft scald (pl. 5, C) are usually caused by secondary infection with *Cladosporium* or *Alternaria*.

Soft scald is apparently due to abnormal respiratory conditions in the apple. It is much more likely to develop at temperatures that border on the freezing point of apples than at those a few degrees higher, and is greatly increased by delay in placing the fruit in storage.

Oiled paper does not control soft scald. Applying a thin coating of paraffin to the fruit decreases the disease. Holding the apples in an atmosphere containing 20 to 30 percent of carbon dioxide for 2 days during the period of cooling has largely or entirely prevented the later development of soft scald. (*22*, *28*, *62*, *100*, *140*, *178*, *179*, *180*, *195*.)

SOGGY BREAKDOWN

Soggy breakdown is a functional disease of apples that sometimes has been included under internal breakdown but appears to be distinct both as to characteristics and cause. Grimes Golden, Wealthy, and Golden Delicious are very susceptible to the disease, whereas Arkansas (Mammoth Black Twig), Willowtwig, and Northwestern Greening appear to be immune.

Soggy breakdown is first evident as light-brown areas in the cortical region of the apple. The discoloration may continue until a large part of the cortex is involved and a complete ring of soft brown tissue formed (pl. 5, D). The affected flesh is sharply defined from the normal and is typically moist and soggy, although sometimes becoming mealy in advanced stages of the disease. The adjacent sound tissue usually has a characteristic fermented taste. The skin of the apple may appear normal except in the later stages of the disease, but affected fruit can be detected by a characteristic sponginess, due to the underlying soft tissue.

Soggy breakdown is akin to soft scald in the conditions responsible for its occurrence. It is more prevalent on apples stored at 30° F. than on those held at 32° and is usually completely prevented by storage at 36° to 40°. It is generally increased greatly by delayed storage.

Holding the apples in an atmosphere containing 20 to 30 percent of carbon dioxide for 2 days during the period of cooling has largely or entirely prevented the later development of soggy breakdown. (*27a*, *177*, *178*, *181*, *182*.)

SOOTY BLOTCH

(*Gloeodes pomigena* (Schw.) Colby)

Sooty blotch is marked by sooty patches or spots, very irregular in size and shape, which may occur on any part of the apple (pl. 3, C, E). They are easily removed by scraping with the finger nail or

a knife blade or by moistening and wiping the apple. On Kieffer pears the blotches are often surrounded by a zone of russet.

The disease causes no decay nor even any browning of the tissues under the spots, but affected fruits are sometimes badly wilted. The chief loss is due to blemishing by the fungus and consequent reduction in the market value of the fruit.

Sooty blotch is common throughout the central, eastern, and northeastern apple-growing regions of the United States, but is rare in the Northwest. All late summer and winter varieties may be affected.

The disease does not develop or spread in transit or in storage and is of minor importance on the market. It is easily controlled by the treatment for scab. (*43*, *100*, *114*, *161*, *183*, *195*.)

SPONGY DRY ROT

(*Volutella fructi* Stevens and Hall)

Spongy dry rot has been reported as causing loss in North Carolina, Massachusetts, New York, West Virginia, Pennsylvania, and Indiana, usually on fallen fruits. It is rare on the market.

In early stages the disease appears as small black spots scattered over the surface of the fruit. Later, as these enlarge, they coalesce to form black sunken areas half an inch to an inch or more in diameter, which eventually become roughened by the fruiting bodies of the fungus. Affected areas resemble those produced by the black-rot fungus, but are firmer and drier and more uniformly black throughout.

The fungus grows very slowly at low temperatures and seems to be unable to penetrate the uninjured skin of apples. (*22*, *100*, *114*, *218*.)

SPRAY INJURY

There are several types of spray injury on the apple. Some of them can be readily attributed to a particular spray material, whereas others have various possible causes.

Russeting is the most common form of spray injury. When it is produced by Bordeaux mixture the skin is often decidedly rough, showing evidence of extreme injury. When caused by arsenicals, lime sulphur, or oils, the injury is likely to be less serious and usually shows finer lines and markings.

Russeting may be due to other agencies than spraying, but the effects are usually somewhat different. Spring frosts often produce a russeting, but the injury is usually found in definite bands and lines around the fruit. Mild forms of russeting may be due to cold spring rains and other unfavorable weather conditions and are sometimes difficult to distinguish from the milder cases of spray injury.

Bordeaux russeting is most likely to result from applications made early in the season (pl. 7, D). Late applications sometimes cause injury in the form of small red or purple pimples, especially on green or yellow varieties such as Yellow Newtown. Varieties most susceptible to roughening and russeting by Bordeaux mixture are Ben Davis, Grimes Golden, and Golden Delicious.

Sulphur injury, from either lime sulphur or other sulphur fungicides, is likely to be worse under high-temperature conditions. Mild cases often take the form of a bronzing or browning of the area most exposed to the sun, whereas severe injury may be exhibited by the formation of hard leathery areas which may or may not slough off (pl. 7, B). The Grimes Golden and Golden Delicious varieties are especially susceptible to injury by lime-sulphur sprays.

In addition to russeting, arsenicals are responsible for another form of injury to the fruit known as calyx injury or blossom-end injury. This appears as a dark-brown or nearly black area around the calyx of the apple, and often furnishes a place of entry for the black-rot fungus or other decay organisms.

Oil sprays cause various types of injury on apple fruits. One of the most common forms is very similar to the calyx injury that results from arsenical sprays. In other cases oil injury is exhibited by russeting and deformation of the apple, which becomes gnarled and roughened. Injury from oil sprays is much more likely to occur on trees suffering from drought or on those low in vigor from other causes. Spraying should be avoided during periods of high temperature (90° F. or above), and care must be exercised at all times to use an acceptable type of oil as well as to have it properly emulsified. (*53*, *56*, *63*, *80*, *102*, *103*, *136*, *148*, *151*, *241*.)

STIGMONOSE

INSECT PUNCTURES

Stigmonose is a general term used to designate a dimpling and distortion of the fruit, a condition which may be caused by a wide variety of insects, chiefly the sucking insects in the group which includes the plant bugs and aphids. The growth of the flesh of the fruit at the point where the feeding punctures occur is more or less retarded, forming characteristic dimples (pl. 19, D). Underneath these dimples will often be found small, roughly hemispherical masses of corky brown tissue (pl. 19, C). Badly affected fruits may be considerably distorted. The injury to the flesh bears some resemblance to bitter pit but can usually be distinguished from it by the fact that the brown masses underneath the spots are generally darker brown and larger than those found in bitter pit. Furthermore, they are always near the surface, whereas bitter-pit spots may be either near the surface or deep within the flesh and in either case are closely connected with the water-conducting system of the apple. The claim has been made that pears affected with plant-bug stigmonose do not keep well in storage, but there is no experimental evidence that this claim is well founded.

An important cause of stigmonose in the Northwest and elsewhere is the tarnished plant bug (*Lygus pratensis* L.). Besides attacking apples, the bugs feed on pears, peaches, and other fruits. On emerging from hibernation in early spring, the bugs feed on the buds, flowers, and newly set fruit. Although most of the injured fruit drops, a certain proportion remains on the tree, and may be very much distorted. In the Northwest, injury is most common on Delicious apples, and on Anjou, Bosc, and Bartlett pears. No

entirely satisfactory method of controlling the tarnished plant bug is known. Except for a brief period in the spring, these bugs live on various herbaceous plants. Clean culture is helpful by eliminating the favored plants on which the bugs breed, but this cannot be recommended where cover crops are considered essential to the orchard-management program.

In the northeastern part of the United States, the apple red bugs (*Heterocordylus malinus* Reut. and *Lygidea mendax* Reut.) are responsible for a great deal of injury of the stigmonose type. These bugs cause less distortion of the fruit than the tarnished plant bug. The newly hatched red bugs appear on the shoots of the apple trees at about the blooming period, and may be controlled by the application of nicotine sulphate in either the pink or the calyx spray, depending on the time when the insects first appear.

The boxelder bug (*Leptocoris trivittatus* Say) also occasionally causes stigmonose. These bugs, which are larger than the tarnished plant bug and marked with red, feed in clusters on maturing fruit. They breed chiefly on boxelder, and when full grown migrate to nearby apple trees. The replacement of boxelder trees in the vicinity of orchards with other kinds of shade trees will prevent injury from this cause.

The rosy apple aphid (*Anuraphis roseus* Baker) also causes a form of stigmonose. These insects feed on the newly formed small apples, and cause them to be very much stunted, knotty, and distorted, usually with a characteristic puckering of the surface around the calyx end (pl. 19, E). The rosy aphid may be controlled by the application of a "delayed dormant" spray at the time when the bud tips show green. The most effective spray consists of three eighths to one half pint of nicotine sulphate (40 percent nicotine) to 50 gallons of water. The nicotine sulphate solution may be added to the concentrated lime-sulphur spray used at this time for the control of San Jose scale. The oil sprays, which have to a considerable extent replaced lime-sulphur for dormant spraying, are less dependable for aphid control, although with the addition of nicotine they are effective when applied in the delayed dormant period. Certain eastern experiment stations are also recommending the use of oil sprays with the addition of 0.5 percent of cresylic acid, at any time during the dormant period.

The apple maggot or railroad worm may cause small dimplelike spots in the surface of the apple as already described, but when the fruit is cut open, small winding tunnels are usually found, extending deep into the flesh (p. 5).

SUNBURN AND SUN SCALD

Apples sometimes exhibit a golden or brown color or a bleached appearance on the side that has been most exposed to the sun. On light-skinned varieties the injury may have much the appearance of an early stage of scald, but the tissue is firm and shows no sign of breakdown. On red-skinned varieties the exposed area is likely to show a browning or bronzing rather than an attractive red.

During storage, sunburned areas often develop an appearance that is difficult to distinguish from scald (pl. 9, E). In other respects the keeping quality of sunburned apples is not materially affected.

The true sun scald is found occasionally as small white or tan-colored, slightly shriveled spots, especially on apples formerly protected but suddenly exposed to the sun. In severe cases, as when an apple lying on the ground has been truly scalded, the skin and flesh present the appearance of having been half-baked in an oven.

WATER CORE

Water core occurs in practically all apple sections of the United States, but is of greatest importance in those regions having an arid or semiarid climate. Among the most susceptible varieties are Yellow Transparent, Rambo, Pumpkin Sweet, Tompkins King, Fall Pippin, Early Harvest, Jonathan, Delicious, Stayman Winesap, Winter Banana, Arkansas (Mammoth Black Twig), and Winesap. The latter variety in the Northwest is more often affected than any other.

Water core is a nonparasitic disease characterized by hard, glassy, water-soaked regions in the flesh of the apple. The disease is more commonly found in the region of the core and of the primary vascular bundles, but may occur in any part of the apple or may involve the whole of it (pl. 8, A). When only the core area is involved it is impossible to detect the disease without cutting the fruit. Visible water core is frequently associated with sunburn.

Water core is particularly bad in regions of intense heat and sunlight. High temperature at the time the apples are approaching maturity is especially favorable to its development. The disease is most likely to occur in fruit that is freely exposed to the sun. It often increases rapidly as the apples become overmature.

Apples that have been bruised while frozen sometimes show soft, water-soaked regions around the injured tissue, but the condition is distinctly different from water core in both texture and location.

Water core not only does not develop or spread in transit or storage but in certain varieties such as Yellow Newtown and Winesap may actually disappear after a few months' storage, particularly if present only in a mild form. When large portions of the flesh are affected, especially in soft-textured varieties like Jonathan, Delicious, Stayman Winesap, and Rome Beauty, there is danger of subsequent breakdown, and prompt disposal of the fruit is advisable (pl. 8, B).

Partial control of the disease can be secured by regulating pruning so as to avoid excessive exposure of the fruit to sunlight, by judicious use of fertilizers to stimulate foliage growth and induce greater shade, and by picking the fruit before it becomes overmature. (*22*, *27*, *66*, *72*, *80*, *100*, *114*, *143*, *186*, *195*, *208*.)

PEARS

AMMONIA INJURY

Exposure to ammonia fumes may be responsible for injury to pears. The trouble is first evident as reddish-brown rings around the lenticels and at abrasions. Upon removal from the atmosphere

containing ammonia the color soon changes to black. In mild cases the injury does not extend beyond the tissue immediately beneath the epidermis. With more severe exposure the lenticel spots may become much enlarged and finally coalesce and the discoloration may extend deep into the flesh.

The presence of moisture is favorable to ammonia injury; pears with a moist surface are more susceptible than those that are badly wilted or those that have a dry surface. Immature pears have been found more susceptible than mature ones. (*117*, *170*, *185*.)

BLACK END

OCCURRENCE AND SYMPTOMS

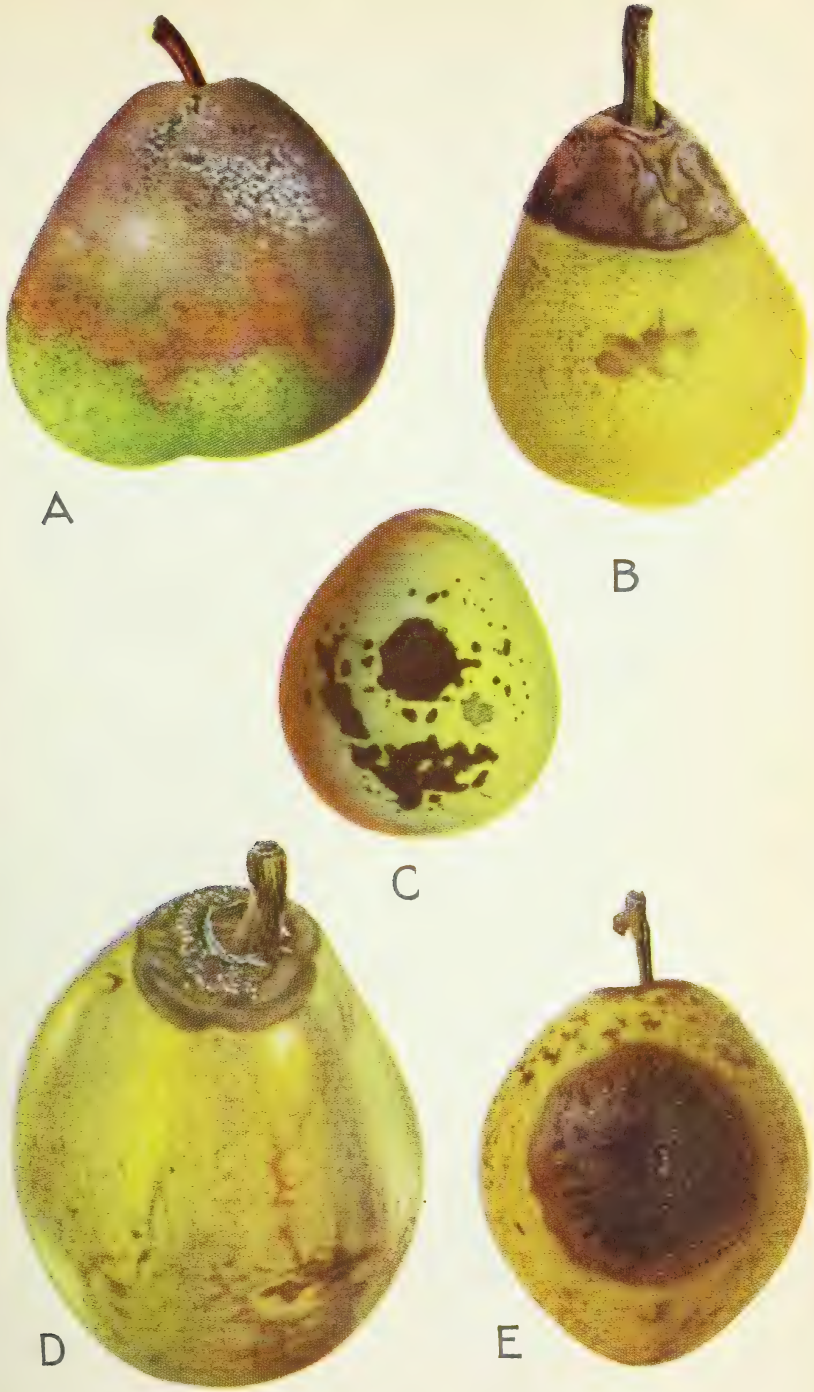
Black end of pears occurs in many of the pear-growing regions of the West and Northwest, but is more common and has caused greater losses in California than elsewhere. Although the disease is found most often on the Bartlett variety, probably because of the greater number of Bartlett trees, it occurs also on other varieties such as Anjou, Winter Nelis, Comice, Easter Beurre, and Clairgeau. Black-end fruits are culled out rather carefully during the grading and packing process and consequently are not often seen on the market.

In the development of the black end, the first symptoms become evident when the fruit is a third to half grown, as a protrusion of the tissues around the calyx and an enlargement of the calyx opening. At this time the epidermis over the affected portion appears tight and shiny. As the disease progresses the calyx lobes turn black, the tissues surrounding the calyx opening become woody, and a brownish discoloration begins to form. This discoloration may appear at first in separate spots, which later coalesce; in other instances a large area may become completely and uniformly discolored from the beginning. The final color of the affected tissues is black. On many specimens the discoloration is confined to an area extending back from the calyx for a quarter to a half of an inch; on some it covers half the surface of the fruit (pl. 14, A, B). The discoloration usually does not extend deep into the flesh and sometimes affects only the skin. Specimens are found occasionally that are not discolored at all but have hard gritty flesh around the calyx and the pointed or peaked appearance that characterizes true black-end fruits. Black end does not develop or spread in storage or in transit.

A black-end condition of apples has been reported from Alabama but is not known to occur on the market.

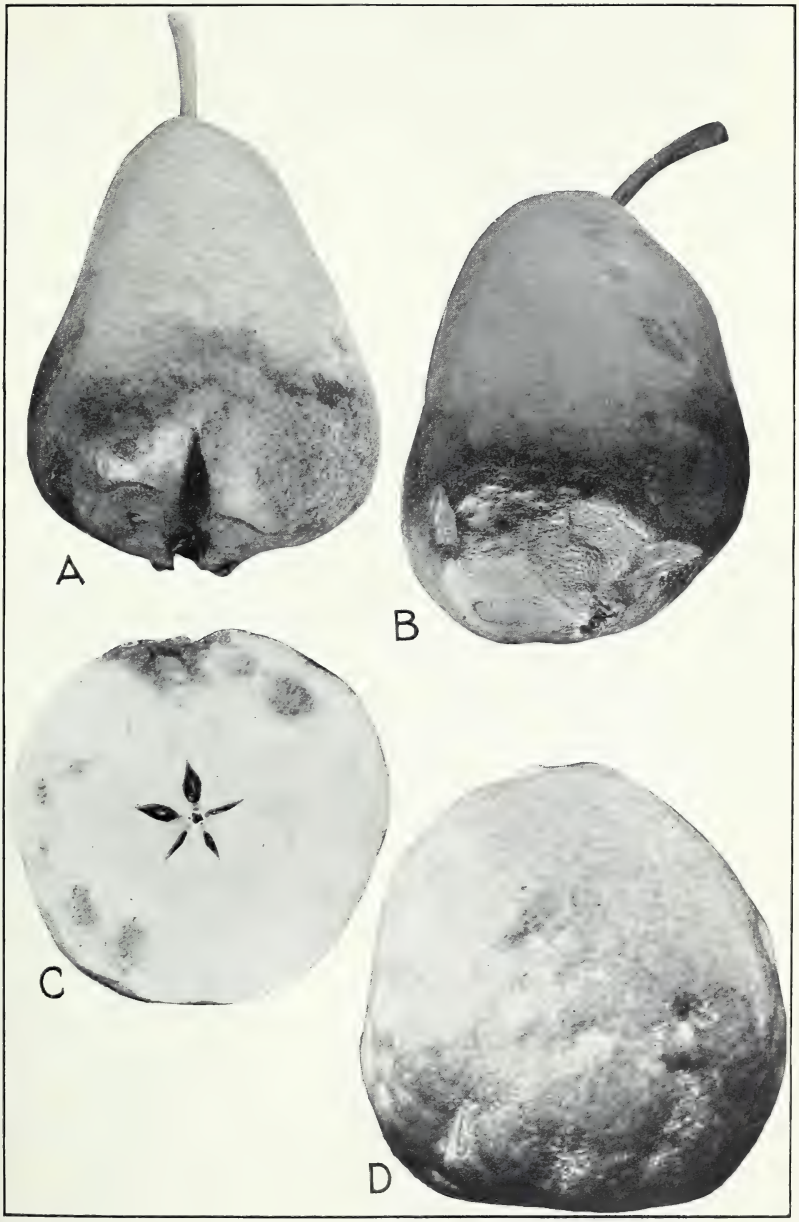
CAUSE

Black end of pears is a physiological disease; that is, no bacteria or fungi are found associated with it. In California, where most of the investigations of it have been made, the disease is found almost exclusively on fruit from trees grown on Japanese (*Pyrus serotina* Rehd.) rootstocks, hence the conclusion has been drawn that this kind of rootstock is in some way the principal cause of the disease. Black-end fruits are occasionally found, however, on trees grown on other rootstocks. There is also evidence that abnormal moisture conditions in the soil or a shallow-lying hardpan favor the development of black end.



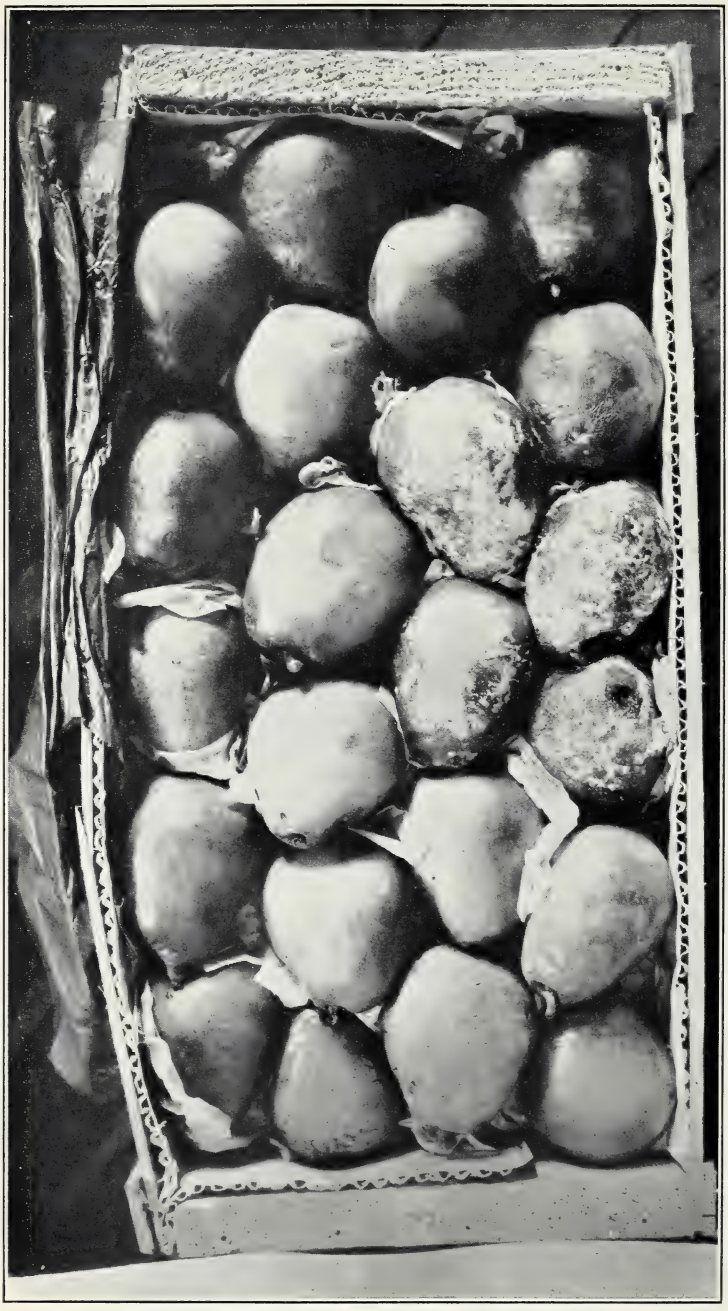
PEAR DISEASES

A, Gray-mold rot on Winter Nelis; B, Rhizopus rot on Bartlett; C, black rot; D, blue-mold rot on Anjou; E, brown rot on Kieffer.



PEAR DISEASES AND INJURIES.

A, B, Pear black end on Bartlett ; C, D, stigmonose on Anjou, caused by tarnished plant bugs.



Gray mold in a box of Anjou pears. Probably started from one infected fruit.

CONTROL MEASURES

Control measures that have been suggested are: (1) The use of some other rootstock than the Japanese on which to graft pears; (2) inarching to change the stock, especially of trees 2 or 3 years old or possibly slightly older, and (3) the improvement of soil conditions where hardpan is found. (*1*, *49*, *106*, *107*, *108*, *109*, *121*, *149*, *238*.)

BLACK ROT

(See Apples, Black Rot, p. 10; pls. 1, B, and 13, C)

BLACK SPOT

(See Quinces, Black Spot, p. 57; pls. 1, D, and 16, D, E)

BLUE-MOLD ROT

(*Penicillium expansum* (Lk.) ex Thom, and possibly other species)

Blue-mold rot of pears (pl. 13, D) usually has the same symptoms as those described for the rot of the same name on apples. There is a form, however, known as pinhole rot, which in its early stages appears as numerous minute spots of decay scattered over the surface of the fruit. Infection apparently takes place at the lenticels in the skin. As the disease progresses the spots increase in size and finally coalesce, so that eventually the fruit becomes entirely decomposed.

Pinhole rot occurs in both washed and unwashed fruit, but is most serious on the Winter Nelis variety. Other varieties are sometimes attacked. Although exact figures are not available as to the amount of loss caused by this disease, the estimate has been made that during the season of 1929–30 it depreciated the value of the Winter Nelis tonnage from certain regions by at least $1 a box.

Pinhole rot is most severe in fruit that is ripened slowly, hence is probably best controlled by maintaining the fruit in a hard green condition while in storage, and ripening it quickly upon removal. (*94*, *100*.)

BROWN ROT

(See Apples, Brown Rot, p. 14; pls. 1, D, and 13, E)

BRUISING

(See under Silicate Injury, p. 55, and pl. 17, A, B, C)

CORE BREAKDOWN

Core breakdown seems to be more serious in some localities than in others, yet the trouble is more or less common to all pear regions, and most varieties of pears are subject to the disease. Clairgeau, Clapp Favorite, Boussock, Early Harvest, Guyot, Jargonelle, Le Conte, Madeleine, and Sudduth have been reported as susceptible under New York conditions. Of the varieties grown in the North-

west, Bartlett, Bosc, Comice, and Clapp Favorite have been found most susceptible, and Anjou and Winter Nelis are rather resistant.

Various names have been applied to the disease by different authors; among these are internal breakdown, core rot, and brown heart. As the various names imply, the disease is characterized by a softening and browning of the tissues in the region of the core (pl. 17, D). The disease may be closely confined to the core or may extend to the surrounding portions of the flesh. Sometimes the softening is most pronounced in a zone about halfway between the center and the outside of the pear. In the incipient form of the disease the affected tissues are soft and watery, and in any stage they have a disagreeable, sickening odor. In late stages the color becomes brownish or black, and in severe cases rapid breakdown and browning of the entire fruit occurs. The internal condition is often associated with a discoloration of the skin resembling scald.

Core breakdown is classed as a market or storage disease of pears, but the time of its occurrence depends largely upon the maturity of the fruit at the time of picking. Experimental tests have shown that it is only the fruit harvested after its best picking time that is likely to become seriously affected later in storage or on the market. (*88*, *89*, *90*, *91*, *142*, *152*, *170*, *225*.)

FREEZING INJURY

When pears of the Bartlett and Anjou varieties are exposed to freezing temperatures for long periods they develop a condition that is fairly definite and positive in its symptoms. In all cases the affected specimens have, externally, a glassy, water-soaked appearance (pl. 18, B). When such fruits are cut the water-soaked condition is seen to be confined to certain portions of the flesh. Usually it is found just beneath the skin and involves several layers of cells. It may also occur within the core area. The remaining flesh is usually dry and pithy, and in cases of severe injury may be badly cracked, so that there are numerous open spaces. This form of the injury has not been seen in other varieties than Bartlett and Anjou.

Pears showing the symptoms just described often remain in an unchanged state for several weeks. They seem to be rather resistant to decay and do not undergo normal breakdown from overmaturity. Affected fruits are inedible and have no commercial value.

The injury has been found to develop in 4 to 6 weeks in pears held at temperatures slightly below their freezing point (23° and 27° F.). (*93*.)

GRAY-MOLD ROT

(*Botrytis* sp.)

Gray-mold rot (pl. 13, A) is one of the most serious storage diseases of pears. The term gray mold is descriptive of the gray mycelium that appears on the fruit in the late stages of decay. The disease is also known as cluster rot, a particularly appropriate name, since a large number of affected fruits are frequently found at one location in the package. The fungus mycelium grows from

one pear to another in such a manner that the rotting fruits are held together, and it is often possible by careful examination to trace the development of large clusters to a single initial rotten pear (pl. 15). Gray-mold rot is darker brown in color than blue-mold rot and the affected tissue is relatively much firmer. It usually has a sour smell.

The casual organism (*Botrytis* sp.) is widely distributed and lives upon a large number of hosts. It is present on decaying matter in the orchard, a circumstance that probably is responsible for much of the infection found in stored fruit. Infection frequently takes place through the stem, starting at the free end. Diseased stems become soft and spongy, and in advanced stages of the decay can be crumbled between the fingers. When pears for storage are not packed immediately after picking, special care should be exercised to sort out any with partially decayed stems or to cut these off below the affected part. Prompt cooling of the fruit reduces the seriousness of the disease, but *Botrytis* is able to continue its growth and produce decay at the usual cold-storage temperature of 32° F.

Good packing-house sanitation and careful handling of the fruit to prevent abrasions and bruises are of value in preventing the development of the disease later in storage. The most practical method of preventing the spread of the rot from one fruit to another is the use of copper-treated wrappers, and this discovery promises to be of great value in reducing the losses from the disease. The wraps, if treated with soluble copper compounds such as copper sulphate, may cause injury if the pears are wet when packed. The injury is exhibited by irregularly shaped black spots scattered over the surface of the fruit (pl. 18, E). (*44*, *45*, *94*.)

PEAR-LEAF BLISTER-MITE INJURY

(*Eriophyes pyri* Pgst.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Two types of injury by the pear-leaf blister mite may be found on pears and also on apples: A diffuse russeting, usually most marked at the calyx end, and irregularly shaped, depressed, brown russeted spots one eighth to one half inch in diameter, most of which are eventually surrounded by a zone of almost decolorized skin (pl. 19, F). Severely infested fruit may be considerably distorted. This mite is widely distributed over the United States, but on the market the injury is seen most often on fruit from the West or Northwest.

CAUSE

The blister mites are microscopic in size, elongate in shape, and have only two pairs of legs. They hibernate under the bud scales, and appear on the foliage as soon as it unfolds. The activities of the mites result in the development of small, blisterlike swellings, which later become brown and dry, giving an appearance of spotting similar to that caused by leaf-spot fungi. Although the most serious damage is to the foliage, the blossoms and young fruit are also attacked.

CONTROL

The blister mite can be controlled by thorough spraying during the dormant period, with winter-strength lime-sulphur, as for the San Jose scale. Oil sprays applied during the dormant season are less satisfactory, although fairly good results have been obtained by using them in warm periods in the spring after the buds have begun to swell (*39*, *67*, *184*, *201*).

PEAR-PSYLLA INJURY

Pears injured by the pear psylla (*Psyllia pyricola* Foerst.) are black in appearance, the result of the growth of a black fungus on the sweet honeydew produced by the insects, which also cause serious injury to the foliage and young growth. The psylla is a tiny, cicadalike insect, about a tenth of an inch long when full grown. Adults hibernate in cracks in the bark of the trunk and limbs, under bark scales, or under trash on the ground in and near the orchard, and migrate to the trees with the very first warm days of early spring. Applications of 3 percent lubricating oil emulsion at this time have given very satisfactory results. Many of the adult flies are killed, and the film of oil on the bark appears to have a great deal of residual value, reducing the number of eggs laid and killing a high percentage of the young psyllas that hatch. Nymphs of the first brood congregate mostly in the axils of the young leaves and fruit and may be treated with a nicotine-soap spray, applied just after the blossoms have fallen, lead arsenate being added for the codling moth.[6]

PINK-MOLD ROT

(See Apples, Pink-Mold Rot, p. 37, and pl. 16, C)

POWDERY MILDEW

(See Apples, Powdery Mildew, p. 38)

RHIZOPUS ROT

(See Apples, Rhizopus Rot, p. 40 and pl. 13, B)

SAN JOSÉ SCALE INJURY

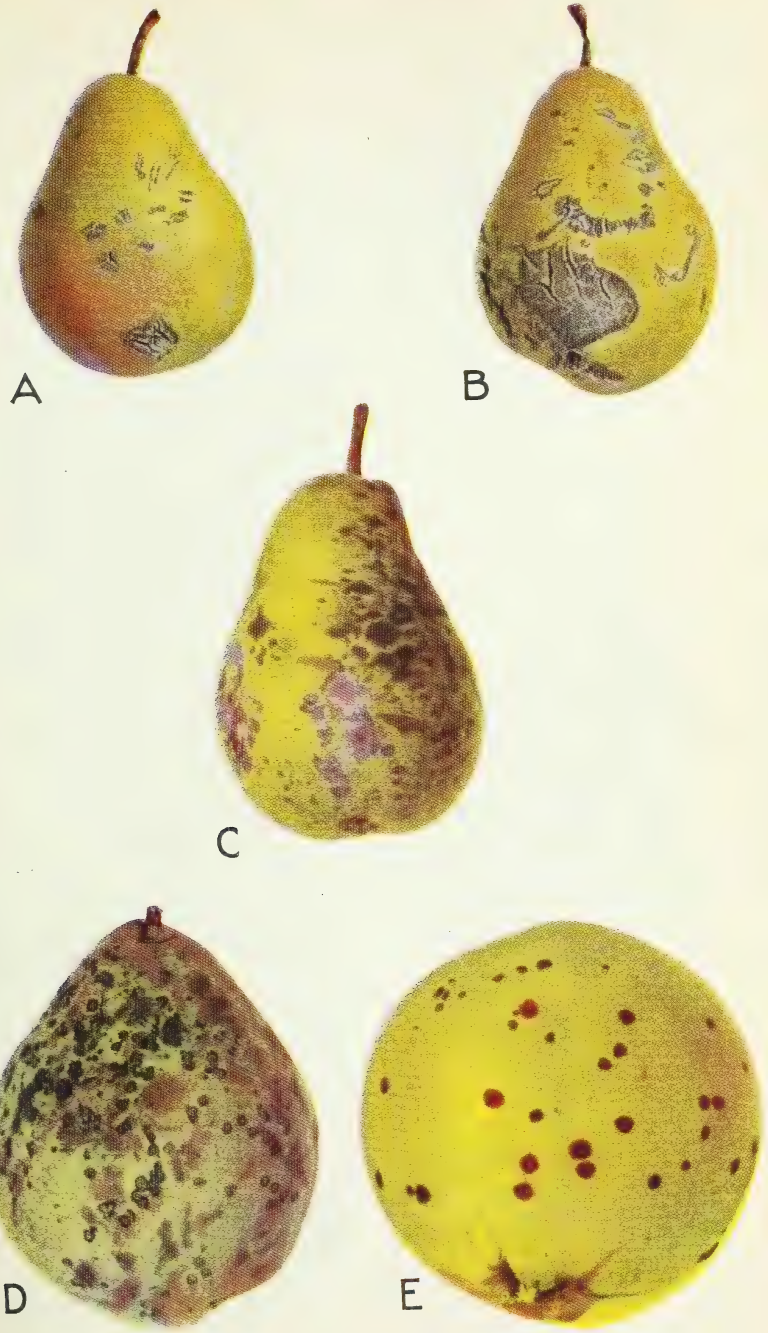
(See Apples, San Jose Scale Injury, p. 40, and pl. 19)

SCAB

(*Venturia pyrina* Aderh)

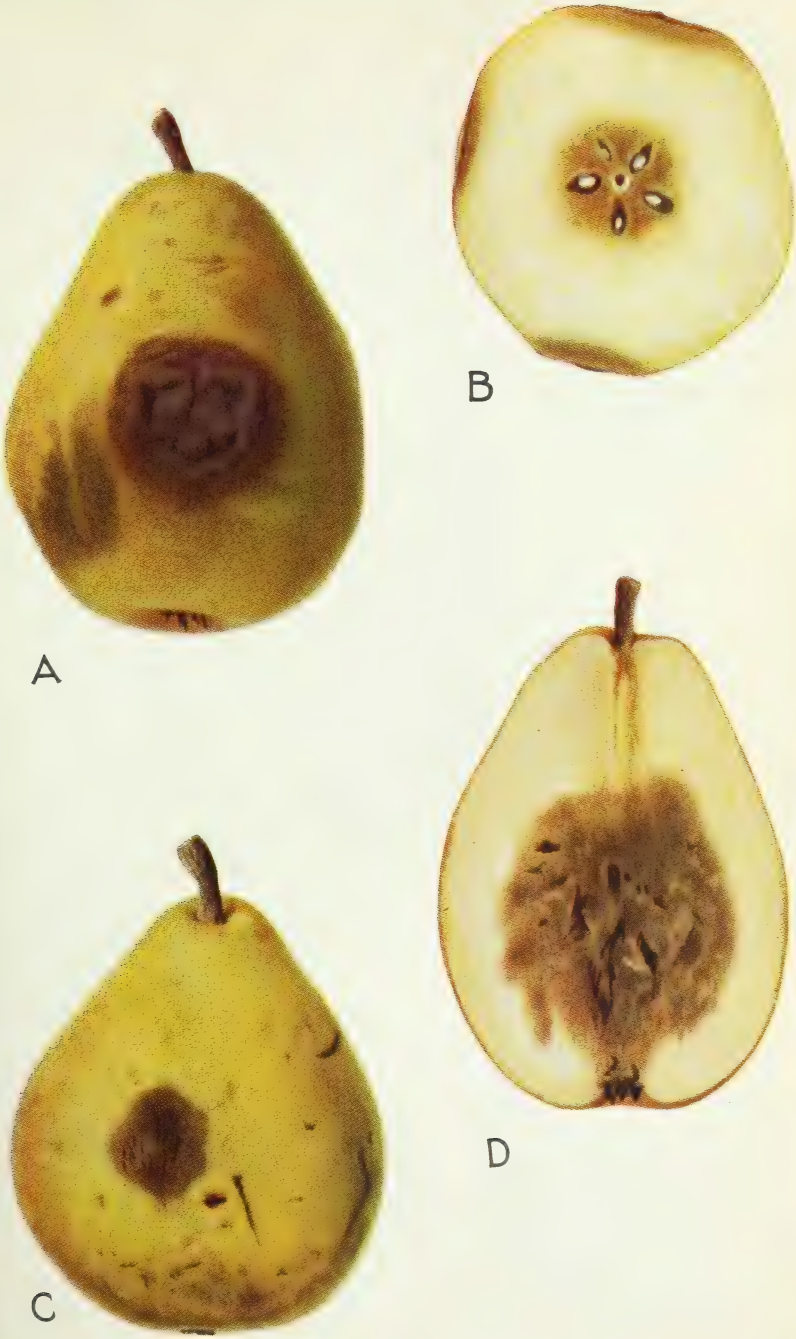
Scab on pears (pl. 16, A, B) is similar to the disease of the same name on apples, although the two are caused by different species of the same fungus. Pear scab usually occurs as larger, rougher spots on the fruit than are common for apple scab and occurs more frequently on the twigs than does apple scab. On Seckel and possibly on other varieties very small scab spots sometimes occur that may be mistaken for other blemishes if not carefully examined.

[6] See statement regarding lead arsenate spray residue, under Codling-Moth Injury, p. 21.



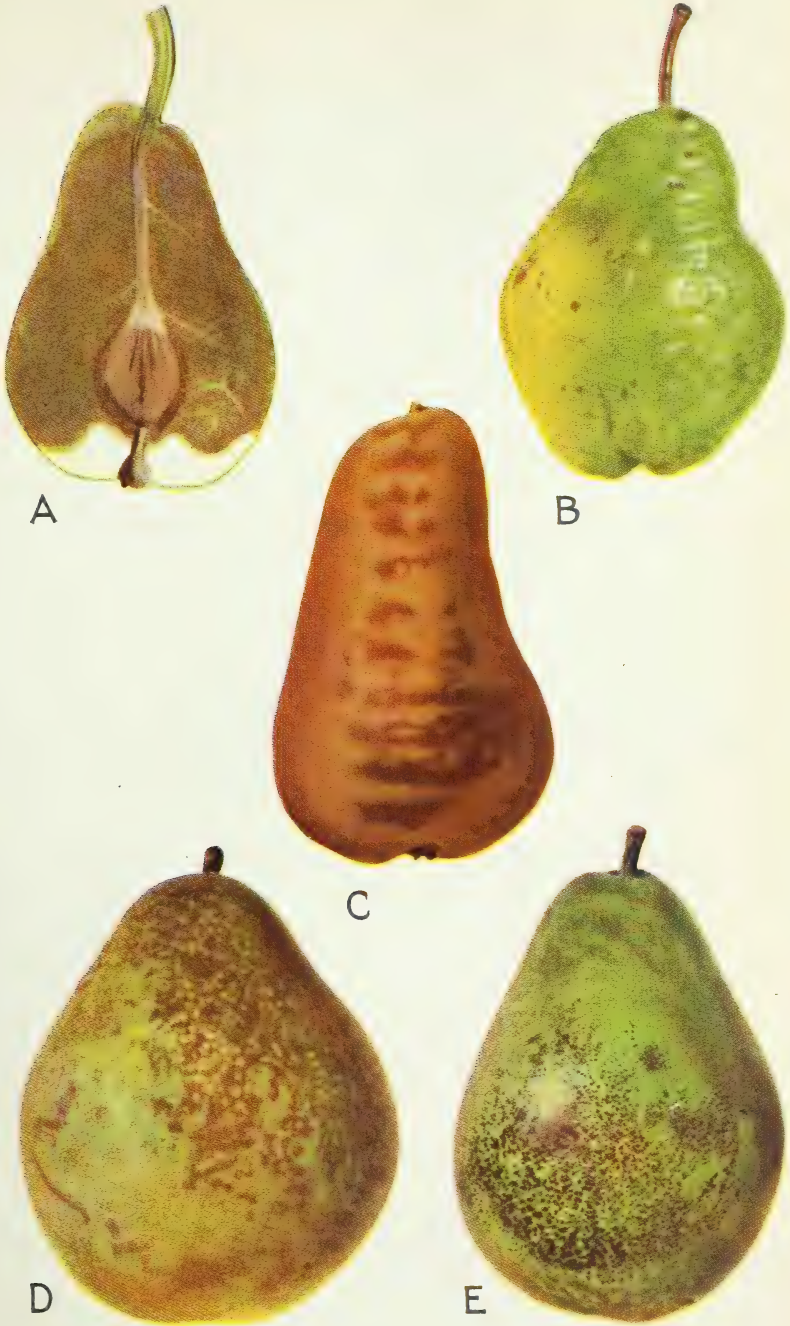
PEAR AND QUINCE DISEASES

A, B, Scab on pear; C, pink-mold rot following scab, on Bartlett pear; D, black spot on pear; E, black spot on quince.



PEAR INJURIES

A, B, Transit bruising on Anjou (pear from floor box); C, injury caused by bruise or rub, on Anjou; D, core breakdown on Anjou.



PEAR INJURIES

A, Smothering injury on Bartlett; B, injury on Bartlett caused by long exposure to temperatures only slightly below the freezing point; C, silicate injury on Bosc; D, Anjou scald; E, injury caused by copper-treated wrapper, on Anjou.

Pear scab is most common and most destructive in the northern parts of the United States east of the Mississippi River. It can be controlled by the treatment recommended for apple scab (p. 41). (*67*, *100*, *104*, *114*, *149*, *122*, *231*.)

SCALD

COMMON FORM

A brown to black discoloration of the skin of Bartlett, Bosc, and some other commercial varieties of pears is known as scald. The disease is apparently much less common on the market than apple scald, and certainly is less understood. Although there is no definite proof that it is caused in the same way as apple scald (p. 44), certain investigations have shown that, like apple scald, it is worse on immature than on mature fruit and is most likely to occur when ventilation is poor. In early stages the disease is entirely superficial, but it progresses rapidly into the flesh at moderate or high temperatures. In late stages the skin becomes weakened and sloughs off readily, so that the scald is very likely to be followed by blue-mold rot and other decays.

The taste and odor of affected fruit are characteristically disagreeable and sickening and can be detected in advance of the appearance of actual discoloration. The ordinary form of scald has been found to develop on pears of the Bartlett variety in 30 to 35 days at 43° F., in 70 to 80 days at 36°, and generally does not develop at all at 31° during the ordinary storage period for this variety. On other commercial varieties, when these are stored at 32°, scald does not usually develop to any serious extent until near the end of their maximum storage period. Oiled paper as used for apple scald has not consistently given control of this common form on pears.

ANJOU SCALD

On Anjou pears scald causes a brown or dark discoloration (pl. 18, D) which detracts materially from the appearance of the fruit, but it is not accompanied by sloughing of the skin nor by unpleasant odors as in the common form described above. The eating quality is not impaired. The condition occurs (1) on both washed and unwashed fruit, (2) on precooled fruit and on fruit that has not been precooled, and (3) on fruit held constantly at 32° F., as well as on fruit held for various lengths of time at other temperatures.

The disease may be controlled by wrapping in oiled paper, so that in these respects Anjou scald seems to be similar to apple scald. (*92*, *94*, *95*, *96*, *139*, *142*, *170*.)

SILICATE INJURY

On certain varieties of pears, both in car-lot shipments just arrived on the market and in cold-storage lots, a brown spotting is sometimes observed that is different in some respects from that caused by rubbing or bruising. It is often found on fruits that have been in contact with the corrugated paper lining the boxes, or with the excelsior-filled pads used in pear boxes to prevent bruising of the fruit.

The spotting is brown in color and usually only superficial and is most pronounced on russeted areas of the skin. It sometimes occurs in bands crosswise of the fruit, corresponding to the corrugations in the paper liner (pl. 18, C), but usually appears merely as irregularly shaped brown spots ¼ to 1 inch in diameter. Varieties on which it has been found are Winter Nelis, Bosc, and P. Barry, all of which show more or less russeting. It has not been found on smooth-skinned pears, although a dark discoloration on Anjou and Bosc pears, the result of pressure or rubbing against the paper liner, the box, or other pears, has sometimes been confused with it.

Silicate injury seems to have no effect on the keeping quality of the fruit.

In some of the corrugated paper used for liners for pear boxes, sodium silicate has been used as a binder to hold the corrugated and the flat sheet together. The silicate contains a small percentage of free alkali, and there is abundant evidence that this is the constituent that causes the injury. Moisture is necessary, and in many instances it seems to be present in sufficient amounts within boxes packed with pears to cause some of the alkali contained in the paper liners to go into solution and produce injury.

The spotting can be avoided by using liners that do not contain free alkali from sodium silicate or any other source. (*197.*)

SMOTHERING INJURY

Attempts have been made from time to time by various persons and commercial organizations to keep pears and other fruits in a fresh state by holding them continuously in closed containers in an atmosphere of nitrogen or carbon dioxide or in air containing a high percentage of carbon dioxide. In some instances a partial vacuum is produced in the container before the carbon dioxide or nitrogen is introduced.

The results obtained from this "gas-storage" method are not always satisfactory, for the reason that it is impossible to bring fruits to a physiological standstill merely by excluding oxygen from the air surrounding them. Oxygen is essential to the normal life processes of plants, and if it is not present, fruits and other live plant parts obtain it by breaking down their own tissues and thus eventually destroy themselves or at least undergo serious deterioration (pl. 18, A).

Injury is produced also if the concentration of carbon dioxide in the container is high from the beginning, or if it becomes high as a result of the respiration of the stored fruit. The latter condition readily develops in containers when no provision is made to keep the composition of the atmosphere in the container constant or to provide sufficient oxygen for the fruit.

Different species of fruits vary in their tolerance for carbon dioxide. The flavor and condition of some kinds of fruit are very readily affected by even 24 hours' exposure to concentrations of 25 percent or more of the gas. This is particularly true of peaches, strawberries, raspberries, and similar aromatic fruits. Other kinds like pears, grapes, and plums are more resistant but not sufficiently so to withstand continuous exposure to such high concentrations of carbon dioxide.

Investigations made in England have shown that the ripening of apples can be retarded without ill effects on the fruit by reducing the amount of oxygen in the air and increasing the amount of carbon dioxide. These results were obtained, however, only when the proportions of oxygen and carbon dioxide in the air of the storage room were kept constant at the figure that had been found most satisfactory (carbon dioxide 10 to 15 percent and oxygen about 10 percent) and the temperature was maintained at approximately 40° F. If the carbon dioxide was allowed to increase beyond 10 percent an internal browning was produced which these investigators called brown heart.

Fruits that have deteriorated badly because of faulty gas storage are usually discolored inside and out and have a fermented odor and taste. (*84*, *115*, *128*, *138*, *141*, *228*.)

SOOTY BLOTCH

(See Apples, Spray Injury, p. 46)

SPRAY INJURY

(See Apples, Sooty Blotch, p. 45)

STIGMONOSE

(See Apples, Stigmonose, p. 47, and pl. 14, C, D)

QUINCES

BLACK ROT

(See Apples, Black Rot, p. 10)

BLACK SPOT

(*Fabraea maculata* (Lév.) Atk.)

Black spot appears as black, circular, slightly sunken spots varying in diameter from about one sixteenth to three eighths of an inch. They are usually surrounded by a red ring, and in late stages may show cracking as in pear scab (pl. 16, E). They may occur on any part of the fruit.

The disease does not develop or spread in storage or transit and is not commonly followed by rot of any kind. It occurs on both pears and quinces and is most common in regions east of the Mississippi River. It has not been reported on fruit from California or the Northwest.

The pathogene causes a spotting of the leaves of pear and quince that is occasionally quite serious, especially on nursery stock.

Commercial control of the disease can be obtained by spraying with lime-sulphur 1 to 50, to which iron sulphate has been added, as a sticker, at the rate of 3 pounds to 50 gallons. The first application should be made soon after the first leaves appear, followed at intervals of about 3 weeks by 3 or 4 other applications. (*5*, *61*, *100*, *114*, *158*.)

BLUE-MOLD ROT

(See Apples, Blue-Mold Rot, p. 12)

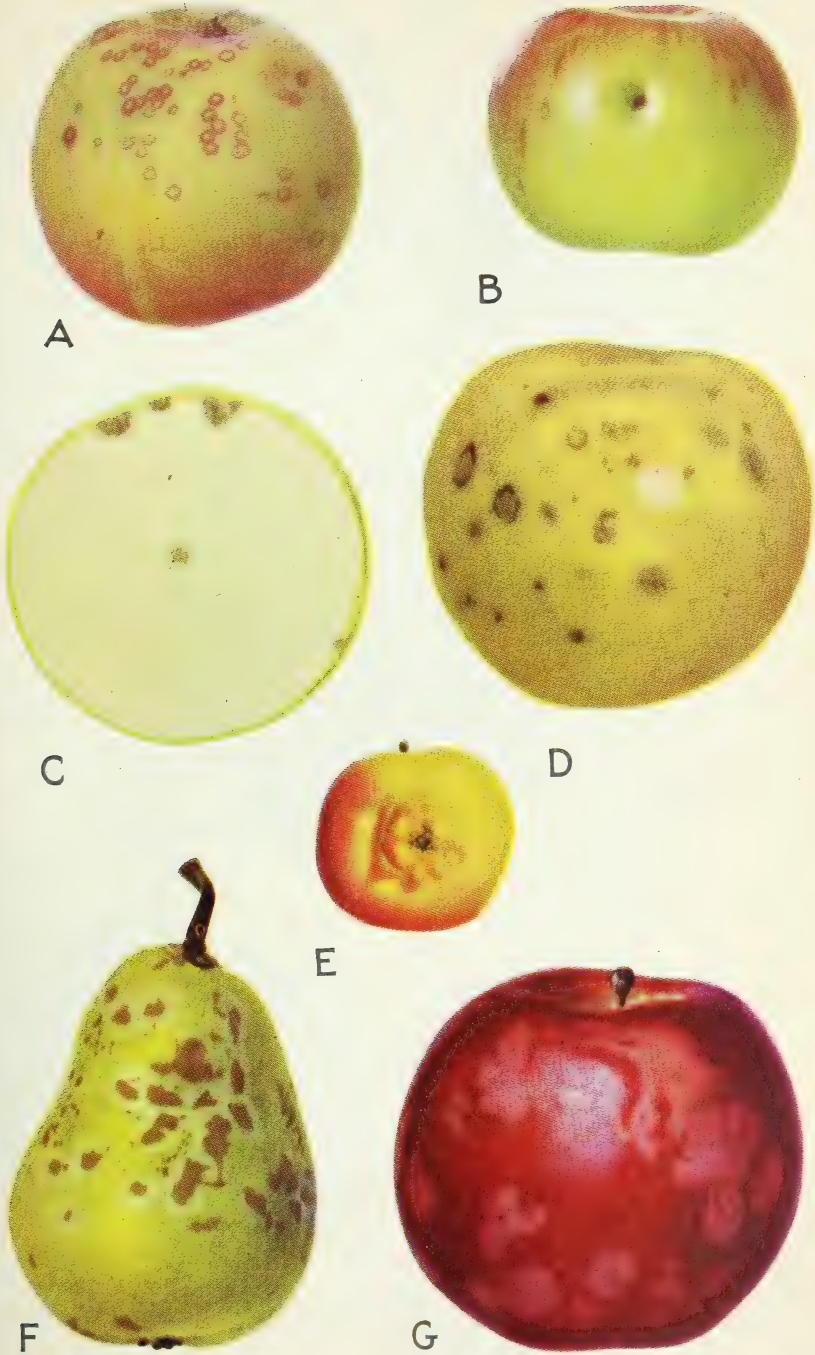
BROWN ROT

(See Apples, Brown Rot, p. 14)

ORIENTAL FRUIT-MOTH INJURY

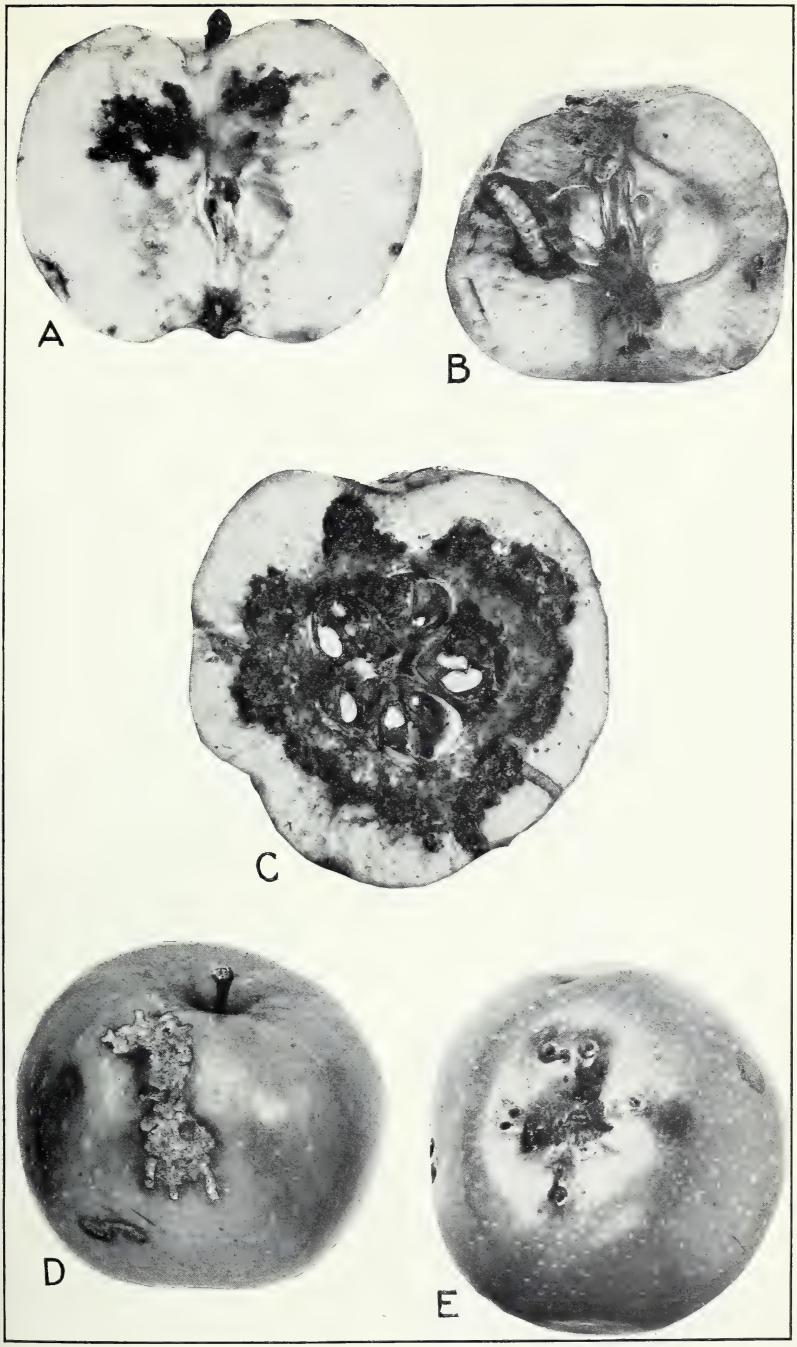
(*Grapholitha molesta* Busck)

Quinces in the eastern part of the United States are often found at harvest time to be completely honeycombed by the tunnels caused by the oriental fruit moth (pl. 20, C). As the name implies, this is an insect of oriental origin. It reached this country about 1910 and now occurs in practically all fruit sections east of the Rockies. Although it has received more notice as a peach pest, it has a particular preference for the quince. A great deal of attention has been given to it by workers in the Department, as well as in the State experiment stations, but adequate control measures cannot yet be recommended. (*184.*)



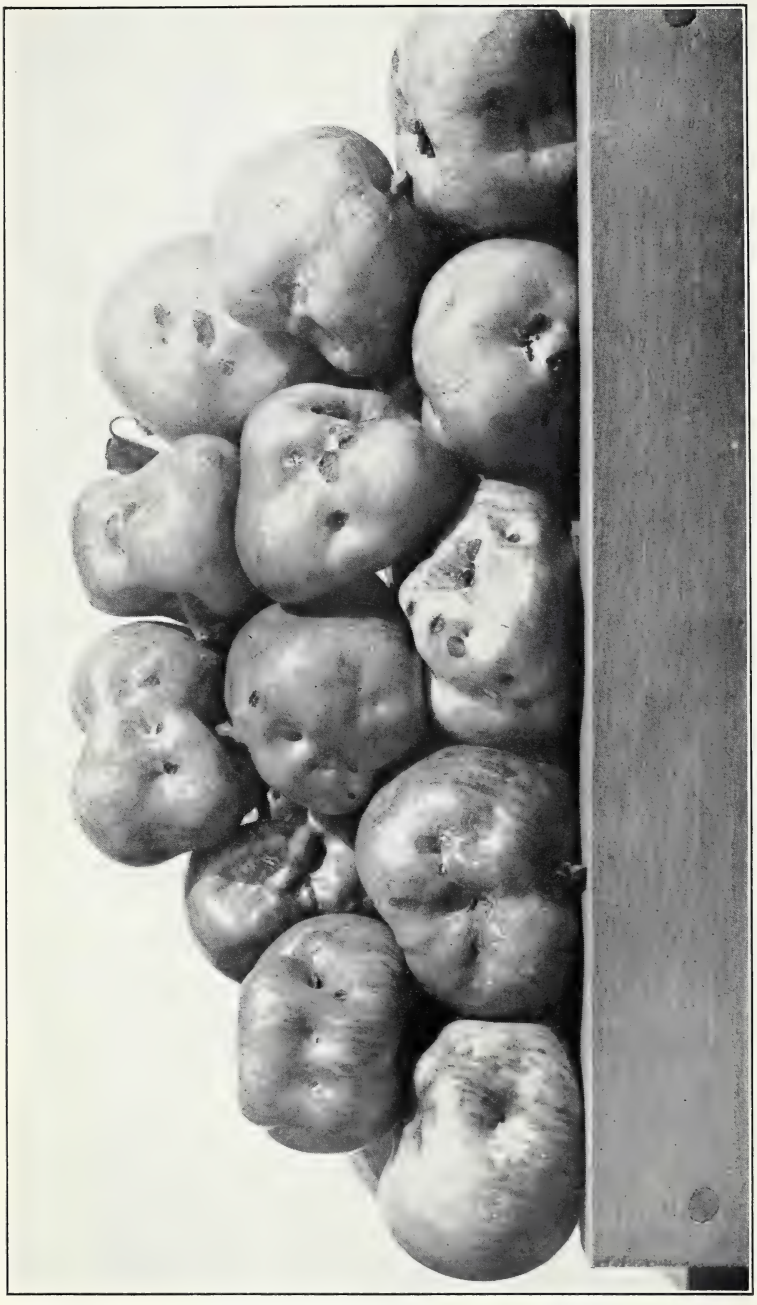
INSECT INJURIES ON APPLES AND PEARS

A, Spotting caused by San Jose scale; B, codling-moth sting injury; C, D, stigmonose injury; E, injury caused by rosy apple aphid; F, pear-leaf blister-mite injury; G, pansy-spot injury on McIntosh.



INSECT INJURIES ON APPLES, PEARS, AND QUINCES.

A, Apple-maggot injury; B, a worm-injured apple showing codling-moth worm in fruit; C, quince severely infested by oriental fruit moth; D, injury by the red-banded leaf roller; E, fall-feeding punctures caused by the plum curculio.



Apples showing typical curculio scarring.

Apples injured by fruit-tree leaf roller.

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